NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agency: Permits, Conservation and Education Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Activity Considered: Biological opinion on the issuance of multiple permits to conduct scientific research on all Atlantic sturgeon DPSs along the Atlantic coast pursuant to section 10 (a)(1) of the Endangered Species Act of 1973

Consultation Conducted by: Endangered Species Act Interagency Consultation Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Approved by: Helen Golde

Date: April 2, 2012

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1531 *et seq.*) requires that each federal agency shall ensure 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 critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat that has been designated for them, that agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the listed resources that may be affected. For the action described in this document, the action agency is NMFS' Office of Protected Resources – Permits, Conservation and Education Division. The consulting agency is NMFS' Office of Protected Resources – Endangered Species Act Interagency Consultation Division.

This document represents NMFS' biological opinion (Opinion) of the effects of the proposed studies on endangered and threatened species, as has been prepared in accordance with section 7 of the ESA. This Opinion is based on our review of the Permits, Conservation and Education Division's draft Environmental Assessment, draft Permits, scientific and technical reports from government agencies and the peer-reviewed literature, and other sources of information.

A complete administrative record for this consultation is on file at NMFS' Office of Protected Resources.

CONSULTATION HISTORY

On October 6, 2010, two proposed listings for Atlantic sturgeon were published (75 FR 61904 Southeast Region; and 75 FR 61872 Northeast Region). Shortly afterward, the NMFS Permits, Conservation and Education Division (PR1) sent out a preliminary notice in October of 2010, asking for Atlantic sturgeon researchers to notify PR1 of their intent to apply for Atlantic sturgeon research permits. On or around February 26, 2011, researchers were formally asked to send in applications with a deadline of April 26, 2011.

While waiting for applications, PR1 worked with the NMFS Endangered Species Act Interagency Consultation Division (PR5) and the Northeast and Southeast Regions on gathering available genetic information and discussing take allocation analyses. However, PR1 and PR5 had to wait until the final listing determination to configure takes per DPS, finalize the permits and Environmental Assessment, and initiate consultation.

Atlantic sturgeon was listed as five DPSs on February 6, 2012 (77 FR 5914 Southeast Region; and 77 FR 5880 Northeast Region). Immediately after listing, PR5 initiated consultation for all submitted permit applications proposing to conduct research on Atlantic sturgeon.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

NMFS PR1 proposes to issue 12 scientific research permits authorizing directed research on Atlantic sturgeon, listed under the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et seq*.), and the regulations governing the taking, importing, and exporting of endangered and threatened species (50 CFR Parts 222-226). The applicants' respective file numbers and location for each permit action area are included in Table 1 below and detailed take tables with proposed take activities for each of the 12 individual permits are depicted in Tables 2-13.

Table 1: List of principal investigators and locations of proposed Atlantic sturgeon research		
Permit Holder & Responsible Party	**File No.**	**Location of Action Area and DPS**
Maine Dept. of Marine Resources/ Gail Wippelhauser	16526	Gulf of Maine Rivers and Coastal Areas (**GOM DPS**)
CT Dept of Environmental Protection/ Thomas Savoy	16323	Connecticut Waters & Long Island Sound (**New York Bight DPS**)
SUNY-Stonybrook/ Keith Dunton	16422	Coastal Waters off Long Island Sound and New Jersey to Delaware River (**New York Bight DPS**)
NY State DEC Kathryn Hattala	16436	Hudson River Estuary: NY Harbor to Troy, NY (**New York Bight DPS**)
Delaware State Univ./ Dewayne Fox	16507	Delaware River and Delaware Coastal Waters (**New York Bight DPS**)
DelawareDNREC/ Stewart Michels	16431	Delaware River Estuary (**New York Bight DPS**)
ERC, Inc/ Hal Brundage	16438	Delaware River Estuary (**New York Bight DPS**)
USFWS/Albert Spells	16547	Chesapeake Bay and Rivers (MD & VA) (**Chesapeake DPS)**
USGS/Joe Hightower	16375	North Carolina Albemarle Sound and Rivers and Cape Fear River (**Carolina DPS**)
SCDNR/ Bill Post	16442	South Carolina Rivers (**Carolina & South Atlantic DPS)**
UGA/Doug Peterson	16482	Georgia Rivers and Coastal Waters (**South Atlantic DPS**)
USGS/Ken Sulak	16508	Florida/Georgia Rivers (**South Atlantic DPS**)

Table 2: Proposed annual take of Atlantic sturgeon for Permit 16526					
Species	**Life Stage**	**Proposed Annual Take**	**Collect Method**	**Proposed Take Activities**	**Location**
Atlantic Sturgeon	Adult/sub-adult	75	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Boroscope; Anesthetize[1]; Internal sonic tag	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Penobscot River

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Lavage	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Penobscot River
Atlantic Sturgeon	Juvenile	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample;	Penobscot River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	D-Net	Directed Mortality	**Penobscot River**
Atlantic Sturgeon	Adult/sub-adult	225	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Internal sonic	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope Anesthetize[1]; Lavage	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Kennebec River
Atlantic Sturgeon	Juvenile	10	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample;	Kennebec River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	100	D-Net	Directed Mortality	Kennebec River

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Internal sonic	Saco River
Atlantic Sturgeon	Adult/sub-adult	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Saco River
Atlantic Sturgeon	Adult/sub-adult	70	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Saco River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Lavage	Saco River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Saco River
Atlantic Sturgeon	Juvenile	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample;	Saco River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	D-Net	Directed Mortality	Saco River
Atlantic Sturgeon	Adult/sub-adult	100	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic sample; Boroscope;	Small Coastal Rivers of ME
Atlantic Sturgeon	Adult/sub-adult	35	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Internal sonic	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize; [1] Lavage	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Merrimack River

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Juvenile	15	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; External sonic tag	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1] Internal sonic	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Lavage	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Boroscope; Blood	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	2 Juveniles 1 Adult[2]	Any Method Authorized	Incidental Mortality or Harmful Injury	Any River or Coastal Area in GOM

1. Anesthesia performed using MS-222 or electronarcosis
2. Mortality of 1 Atlantic sturgeon adult over the life of the permit.

Table 3: Proposed annual take of Atlantic sturgeon for Permit 16323

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	125	Gill Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Connecticut waters and Long Island Sound
Atlantic Sturgeon	Adult/sub-adult	75	Gill Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal sonic tag	Connecticut waters and Long Island Sound

Table 4: Proposed Annual Take for Permit No. 16422

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	100	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize, Internal sonic tag	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	100	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize, Internal sonic tag; and Fin ray clip	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	100 Total of 300/5yr	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Blood sample; Gastric lavage; Gill biopsy	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	20	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; External/PSAT tag	Long Island Sound, New York, New Jersey Coast
Species	**Life Stage**	**Proposed Annual Take**	**Observe/ Collect Method**	**Proposed Take Activities**	**Location**
Atlantic Sturgeon	Adult/sub-adult	5	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Blood sample; Body tissue biopsy*	Long Island Sound, New York, New Jersey Coast

*Procedure would only be performed on fish exhibiting parasitic copepods in body of sturgeon.

Table 5: Proposed take of Atlantic sturgeon for Permit 16436

Species	Life Stage	Proposed Annual Take	Observe Collect Method	Proposed Take Activities	Details	Location
Atlantic Sturgeon	Juvenile	260	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample	Project 1 Juvenile Abundance Survey (350-1000 mm) (Year 1-5)	Hudson River
Atlantic Sturgeon	Juvenile	40	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue; Anesthetize; Lavage	Project 1 Juvenile Abundance Survey (350-1000 mm) (Year 1-5)	Hudson River
Atlantic Sturgeon	Juvenile	2	Gill Net	Unintentional Mortality	Project 1) Juvenile Abundance Survey (Year 1-5	Hudson River
Atlantic Sturgeon	Adult	150	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue	Project 2: Adult Spaw Stock (>1,000 mm) Characteristics (Year 1-5)	Hudson River

Species	Life Stage	Proposed Annual Take	Observe Collect Method	Proposed Take Activities	Details	Location
Atlantic Sturgeon	Adult	25	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue; Internal acoustic tag	Project 2: Adult spawning Stock (>1,000 mm) Characteristics (Year 1-5)	Hudson River
Atlantic Sturgeon	Adult	25	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue; External acoustic tag	Project 2: Adult spawning Stock (>1,000 mm) Characteristics (Year 1-5)	Hudson River
Atlantic Sturgeon	Juvenile	25/50*	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; External acoustic tag	Project 3: Age-1 (<350mm) Population Estimate (Year 1-3)	Hudson River
Atlantic Sturgeon	Juvenile	1,000	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue	Project 3: Age-1 (<350mm) Population Estimate (Year 4-5)	Hudson River

*25 age-1 juvenile are proposed to be tagged in year 1 and 50 each in years 2 and 3.

Table 6: Proposed take of Atlantic sturgeon for Permit 16438					
Species	**Life Stage**	**Proposed Annual Take**	**Observe Collect Method**	**Proposed Take Activities**	**Location**
Atlantic Sturgeon	Juvenile	200	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal sonic tag	Delaware River
Atlantic Sturgeon	Juvenile	24	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Blood sample; Laparoscopy	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Gastric lavage	Delaware River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat	Intentional (Directed) Mortality	Delaware River
Atlantic Sturgeon	Juvenile	1	Gill Net, Trammel Net, Trawl Net	Unintentional Mortality	Delaware River

Table 7: Proposed take of Atlantic sturgeon for Permit 16507						
Species	**Life Stage**	**Proposed Annual Take**	**Observe Collect Method**	**Proposed Take Activities**	**Details**	**Location**
Atlantic Sturgeon	Early Life Stage (Eggs/ Larvae)	50	Egg Mat	Directed Mortality, (Preserved as laboratory samples)	Project 1: Spawning Site Identification	Delaware Bay and Offshore
Atlantic Sturgeon	Early Life Stage (Eggs/ Larvae)	300	Egg Mat	Take--Enumerated and returned to river	Project 1: Spawning Site Identification	Delaware Bay and Offshore
Atlantic Sturgeon	Juvenile	100	Gill Net	Measure; Weigh; Photograph; PIT tag; Genetic tissue sample	Project 2: Hydroacoustic Assessment	Delaware Bay and Offshore
Atlantic Sturgeon	Adult/ Juvenile	300	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Project 3: Fishery Independent Monitoring/Coastal Sampling Program	Delaware Bay and Offshore
Atlantic Sturgeon	Adult/ Juvenile	60	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Fin ray sample; Anesthetize; Internal sonic tag[1] Gonad tissue sample	Project 3: Fishery Independent Monitoring/Coastal Sampling Program	Delaware Bay and Offshore
Atlantic Sturgeon	Adult/ Juvenile	50	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Fin ray sample; Anesthetize; Pop-off satellite archival tag[2] Gonad tissue sample	Project 3: Fishery Independent Monitoring/Coastal Sampling Program	Delaware Bay and Offshore

1. Only Atlantic sturgeon >60.0cm fork length would be implanted with a sonic tag.
2. PSAT tags are slated for Year 2 – 5 of the permit.

Table 8: Proposed take of Atlantic sturgeon for Permit 16431.					
Species	**Life Stage**	**Proposed Annual Take**	**Observe/Collect Method**	**Proposed Take Activities**	**Location**
Atlantic Sturgeon	Juvenile	150	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal sonic tag	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Gastric lavage	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip;	Delaware River
Atlantic Sturgeon	Juvenile	1*	Gill Net	Unintentional Mortality	Delaware River

*Not to exceed 1 unintentional mortality over the life of the permit

Table 9: Proposed take of Atlantic sturgeon for Permit 16547.					
Species	**Life Stage**	**Proposed Annual Take**	**Observe/ Collect Method**	**Proposed Take Activities**	**Location**
Atlantic Sturgeon	Adult/ Juvenile	100	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Anesthetize[1]; internal sonic tag; PIT tag; Measure; Photograph or Video; fin clip; Weigh	Chesapeake Bay, MD & VA (All saline portions of Chesapeake Bay including coastal areas measuring above 22ppt salinity)
Atlantic Sturgeon	Adult/ Juvenile	100	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	External sonic tag; PIT tag; Measure; Photograph or Video; fin clip; Weigh	Chesapeake Bay, MD & VA (All saline portions of Chesapeake Bay including coastal areas measuring above 22ppt salinity)
Atlantic Sturgeon	Adult/ Juvenile	75	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	External sonic tag, Floy T-bar; PIT tag; Measure; Weigh; Photograph-Video; Fin clip	Chesapeake Bay & tributaries (James, York, Rappahannock Potomac Patapsco Patuxent, Chester, Choptank, Nanticoke Susquehanna & Pocomoke).

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Juvenile	25	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	External sonic tag; Floy T-bar; PIT tag; Fin clip Measure; Weigh, Photograph Video	Chesapeake Bay & tributaries (James, York, Rappahannock Potomac Patapsco Patuxent, Chester, Choptank, Nanticoke Susquehanna & Pocomoke).
Atlantic Sturgeon	Juvenile	150	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph Video; Sample, fin clip; Weigh	Chesapeake Bay & tributaries (James, York, Rappahannock Potomac Patapsco Patuxent, Chester, Choptank, Nanticoke Susquehanna & Pocomoke).
Atlantic Sturgeon	Adult/ Juvenile	150	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph Video; Sample, fin clip; Weigh	Chesapeake Bay & tributaries (James, York, Rappahannock Potomac Patapsco Patuxent, Chester, Choptank, Nanticoke Susquehanna & Pocomoke).
Atlantic Sturgeon	Eggs or Larvae	25	Egg mat	Intentional (directed) mortality	Chesapeake Bay & tributaries (James, York, Rappahannock Potomac Patapsco Patuxent, Chester, Choptank, Nanticoke Susquehanna & Pocomoke).
Atlantic Sturgeon	Adult/ Juvenile	2 Juvenile 1 Adult[2]	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Unintentional Mortality	Chesapeake Bay & tributaries, including all fresh and saline riverine and coastal areas.

1. Anesthesia performed using MS-222 or electronarcosis

2. Mortality of 1 Atlantic sturgeon over the life of the permit.

Table 10: Proposed take of Atlantic sturgeon for Permit 16375.

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/ Juvenile	45	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal acoustic tag;	Albemarle Sound, Roanoke & Chowan Rivers
Atlantic Sturgeon	Adult/ Juvenile	55	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Albemarle Sound, Roanoke & Chowan Rivers
Atlantic Sturgeon	Adult/ Juvenile	45	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal acoustic tag;	Cape Fear River Basin
Atlantic Sturgeon	Adult/ Juvenile	55	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Cape Fear River Basin

Table 11: Proposed take of Atlantic sturgeon for Permit 16442.					
Species	**Life Stage**	**Proposed Annual Take**	**Observe/Collect Method**	**Proposed Take Activities**	**Location**
Atlantic Sturgeon	Adult/sub-adult	100	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample	Santee-Cooper Watershed; and Winyah Bay Watershed
Atlantic Sturgeon	Adult/sub-adult	60	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Internal acoustic tag; Gonad biopsy	Santee-Cooper Watershed; and Winyah Bay Watershed
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat	Directed Mortality	Santee-Cooper Watershed; and Winyah Bay Watershed
Atlantic Sturgeon	Adult/sub-adult	100	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample	Savannah River and ACE Basin Watershed
Atlantic Sturgeon	Adult/sub-adult	90	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Internal acoustic tag; Gonad biopsy	Savannah River and ACE Basin Watershed
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat	Directed Mortality	Savannah River and ACE Basin Watershed

Table 12: Proposed Annual Take for Permit No. 16482

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	40 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Savannah River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Savannah River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure;Weigh; Photograph;PIT tag; Floy/T-bar tag;Genetic tissue sample;Anesthetize; Laproscopy;Internal tag	Savannah River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Anesthetize; Lavage	Savannah River
Atlantic Sturgeon	Juvenile	910	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue	Savannah River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Lavage	Savannah River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Anesthetize; Internal/External tag	Savannah River
Atlantic Sturgeon	Juvenile	50	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Anesthetize; Fin ray clip	Savannah River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Intentional (Directed) Mortality	Savannah River
Atlantic Sturgeon	Adult/sub-adult	40 Total of 120/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue	Ogeechee River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Ogeechee River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Anesthetize; Internal acoustic tag Laproscopy; Gonad biopsy	Ogeechee River
Atlantic Sturgeon	Juvenile	60	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Ogeechee River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Ogeechee River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal/External acoustic tag	Ogeechee River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Directed Mortality	Ogeechee River
Atlantic Sturgeon	Adult/sub-adult	60 Total of 180/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue Anesthetize; Fin ray	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Gonad biopsy; Anesthetize; Laproscopy; Internal acoustic tag	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue Anesthetize; Lavage	Altamaha River
Atlantic Sturgeon	Juvenile	1910	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Altamaha River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Altamaha River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal/External acoustic	Altamaha River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Lavage	Altamaha River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Intentional (Directed) Mortality	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Satilla River
Atlantic Sturgeon	Adult/sub-adult	10 Total of 30/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue ; Anesthetize; Gonad biopsy; Laparoscopy; Internal acoustic tag	Satilla River
Atlantic Sturgeon	Juvenile	60	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Satilla River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Satilla River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue Anesthetize; Internal/External acoustic	Satilla River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Directed Mortality	Satilla River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	St. Marys River
Atlantic Sturgeon	Adult/sub-adult	10 Total of 30/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Gonad sample; Anesthetize; Laproscopy; Internal acoustic tag	St. Marys River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Juvenile	60	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	St. Marys River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	St. Marys River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal/External acoustic	St. Marys River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Directed Mortality	St. Marys River
Atlantic Sturgeon	Juvenile Adult	5* 1	Gill Net, Trammel Net	Unintentional Mortality	All Rivers

*Unintentional mortality or serious injury cannot exceed 5 juvenile annually or 1 adult Atlantic sturgeon in all rivers annually.

Table 13: Proposed take of Atlantic sturgeon for Permit 16508

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Location
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net*	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; External sonic tag	St. Marys River
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net*	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; External sonic tag	Nassau River
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net*	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; External sonic tag	St. Johns River

*The applicant would use side scan sonar first to locate specimens, and then would deploy gill nets to capture sturgeon.

Research methods

All sampling and handling of sturgeon would be conducted following the guidelines established in "A Protocol for the Use of Shortnose and Atlantic Sturgeon" (Moser *et al.* 2000a), and as further amended by NMFS in "A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons" (Kahn and Mohead 2010). The 12 research permits would contain a wide array of research techniques (Table 14); those techniques are identified and explained below as well as in Kahn and Mohead (2010).

Table 14: Proposed research activities for each Permit

Activity	Capture	Measure	Weigh	Photograph	PIT Tag	Genetic Tissue	Dart Tag	T-bar/Floy Tag	External Sonic	Anesthesia	Internal Sonic	PSAT Tag	Laparoscopy	Boroscopy	Gonad Biopsy	Blood Sample	Fin Ray Section	Gastric Lavage	Gill Biopsy	Hydroacoustic	ELS Sample
File No.																					
16526 MEDMR	X	X	X	X	X	X		X		X	X			X		X	X			X	X
16323 Savoy CT DEP	X	X	X	X	X	X		X		X	X						X				
16422 Dunton SUNY	X	X	X	X	X	X	X			X	X	X			X	X	X	X	X		
16436 Hattala NYSDEC	X	X	X	X	X	X	X		X	X								X			
16438 Brundage ERC	X	X	X	X	X	X		X		X	X		X			X		X		X	X
16507 Fox DELAWARE ST.	X	X	X	X	X	X		X		X	X						X			X	X
16431 Fisher DE DFW	X	X	X	X	X	X		X									X	X			
16547 USFWS VA & MD	X	X	X	X	X	X			X	X	X										X
16375 Hightower USGS/ NC STATE	X	X	X	X	X	X		X		X	X										
16442 Post SC DNR	X	X	X	X	X	X	X			X	X				X						X
16482 Peterson UGA	X	X	X	X	X	X	X			X	X		X	X		X	X	X			X
16508 Sulak USGS GA & FL	X	X	X	X	X	X		X	X											X	

Capture

Depending upon the targeted life stage, PR1 proposes to authorize a variety of capture techniques for Atlantic sturgeon. The location of the sampling (e.g., river, offshore coastal waters) and the bottom type (e.g., mud, sand, rocks) also play a role in the type of gear selected for use. Gill nets are the most commonly used gear in fishing for adult and juvenile Atlantic sturgeon. Trammel nets are similar in appearance to gill nets, but are used less often in targeting adults and juveniles. Trawls are also useful in capturing these life stages and can also be adapted to collect smaller young of the year sturgeon. To target sturgeon eggs and early life stage (ELS) fish, researchers would use D-nets or artificial substrate egg mats. The applicants would be

required to adhere to mitigation measures as highlighted in the standard conditions of their respective permits.

To insure the safety of the sturgeon captured in gillnets and trammel nets, researchers would adhere to standard environmental conditions related to net set duration and DO concentration during sampling (Kahn and Mohead 2010) as summarized below in Table 15. Nets would be attended during daylight hours to avoid marine mammal and sea turtle interactions where documented, and in waters having minimum dissolved oxygen (DO) concentrations of 4.5 mg/L. Netting would typically cease above 28°C water temperature. However, in File 16442, 16482 and 16508 (South Carolina, Georgia and Florida waters) a varying netting protocol would be authorized where soak times would be reduced to 30 minutes at water temperatures between 28 and 30°C and/or DO concentrations between 4.0 and 4.5 mg/L.

Anchored Gillnets. Atlantic sturgeon would be captured with anchored gill nets sets fishing off the bottom (usually about 1.8m up from the substrate) and in a variety of depths (but a general range would be from 10-60 feet deep). Gill net mesh size would vary by project, but would commonly be 10-18cm (stretch measure), and would be appropriate for the size (i.e., life stage) of sturgeon targeted.

Drift Gillnets. Drift gill nets would also be set on the bottom perpendicular to the prevailing flow and allowed to move with the prevailing flow for a short period of time, depending on the tides, generally between 30 minutes and 1.5 hours. Water quality conditions for drift nets would be the same as for anchored gillnets; however, all drift net sets would be continuously tended because of the risk of gear entanglement or loss of gear. Also, drift gillnets would be pulled immediately if it were obvious a sturgeon or non-target listed animal had been captured

Trammel Nets. Trammel nets would typically consist of mesh sizes of 2-4 inches for the inner panes, and 8-12 inches in the outer panels, although experimental trammel nets would vary depending on the targeted animal. Netting material would consist of heavy multifilament nylon mesh instead of monofilament or light twine. Trammel nets would be fished in water depths comparable to gill nets. Due to their similarity, the same standardized netting protocol as described above for gill nets would be followed.

Table 15: Summary of general netting conditions (Kahn and Mohead 2010)

	Water Temperature (°C)	Minimum DO (mg/L)	Net Set Duration (hr)
1	≤15	4.5	10[1]
2	15 ≤ 20	4.5	3
3	20 ≤ 25	4.5	2
4	25 ≤ 28	4.5	1
5[2]	28 ≤ 30	4.0	0.5

1. Nets must be attended during daylight hours unless otherwise authorized in permits.
2. Environmental conditions apply to researchers in SC, GA and FL.

Trawls. Dovel and Berggren (1983) found small trawls effective while collecting multiple life stages of sturgeon in a variety of habitats of sand and mud bottoms, and flat stretches free of debris. Small skiff trawls (5.1 or 8cm mesh, 10m headrope) would be used by applicants in the main stems of rivers and at the mouths of rivers in Connecticut waters (File

16323). Trawling would be performed year round, subject to the same netting environmental conditions with respect to temperature and DO. They would typically be set and hauled by hand and towed at speeds between approximately 1 to 2.5 knots for 5-15 minutes using a boat equipped with a small (e.g., 5.2 or 6.4hp) outboard engine.

Trawling for juvenile Atlantic sturgeon would similarly be performed in the tidal Delaware River from Artificial Island to Trenton (rkm 79-215) using a 4.9 m otter trawl and/or a 14.6 m yankee trawl (File 16438). Likewise, smaller epibenthic trawls, referred to as "Missouri trawl", would be authorized within the Merrimack River, Massachusetts in Maine Rivers and in South Carolina and Georgia Rivers. Although no trawling for young juvenile Atlantic sturgeon has been attempted in the Merrimack River thus far, the technique has proven successful for capturing juveniles (30.0 cm TL) and adults in the Connecticut River (Savoy and Benway 2004) and YOY pallid and shovelnose sturgeon in the Mississippi River (Phelps *et al.* 2010). Additional modifications of the "Missouri" style bottom trawl to protect small, soft-bodied fish are described by Herzog *et al.* (2005).

Larger otter trawls would be used in offshore environments, primarily on sand bottoms along the coastal areas off Long Island Sound, New Jersey and Delaware (File 16422). The same trawl would also be used in portions of the lower Hudson River. These nets would have a longer headrope than the skiff trawls (25m) and larger mesh (8 or 12cm) and would be equipped with steel doors (6'x4', 739lbs.). Trawl times would be similar (5-20 minutes), but due to the environment, tow speeds would be faster than in the rivers, between 3-3.5 knots. Because of their size, these otter trawls would be mechanically hauled.

Pound Nets, Fyke Nets, Hoop Nets or other Trapping Nets. PR1 would authorize pound, fyke or hoop nets (File 16547) in Maryland and Virginia waters in the Chesapeake Bay. The gear would be fished in accordance with state regulatory code and only in waters allowed seasonally or as otherwise mandated by the state agencies. In general, such trapping gear is stationary fishing gear beginning with a length of netting called the "leader," stretching out perpendicular from the shoreline. The mesh leader is suspended between rows of pilings permanently sunk into the seabed. A weighted chain along the bottom of the net hugs the leader to the bay floor while the net's top is held up by the pilings. The leader does not actively capture fish; instead, it spans the depth of the water column, diverting fish away from shore and into the trap — or pound — located offshore. Fyke nets are bag-shaped nets which are held open by hoops. These are typically linked together in long chains and equipped with wings and leaders. However, where applicable, these gear types would be excluded in permits when temperatures are above 18^{o}C to prevent sea turtle interactions between May and November. Additionally, these gears would be fished to same environmental and handling conditions. The maximum set duration would be 14 hours when water temperature is less than 15^{o}C.

Beach Seine. Beach seines operated from the shore are proposed as a capture method for Atlantic sturgeon in the Gulf of Maine (GOM) (permit 16526). This gear is proposed for targeting young of year or juvenile fish foraging along flat sandy areas of rivers and estuaries that are not able to out-swim the hauling action of the seine. The seine is lengthened by long ropes for towing when encircling fish and drawing them to the beach. The seine is therefore a barrier preventing the fish from escaping from the area enclosed by a centered bag portion of the

net when surrounded. The headrope of the seine (~30 meters long) is fitted with floats on the surface and the footrope remains in permanent contact with the bottom weighted leaded line. When setting the seine, the first towing line is fastened ashore, and then the lead wing is set out in shallow water in a wide arc and brought back to the beach. The bottom and surface act as natural barriers preventing young sturgeon from escaping from the area enclosed by the net. The drag lines are towed simultaneously from the beach and the fish are herded in front of the bag. When the ground ropes reach the beach first, the catch is gathered in the bag by bringing the gear underneath the fish. The bycatch would be sorted and returned to the water and all sturgeon would be measured and weighed and PIT tagged, if properly sized.

Egg Mats. To collect Atlantic sturgeon early life stages (ELS), artificial substrate samplers or egg mats would be deployed downstream of purported spawning areas to verify spawning activity in spring or fall months. The egg mats would be circular polyester floor-buffing pads anchored to the bottom able to passively collect eggs adrift at the spawning site (McCabe and Beckman 1993). These would be checked and reset at least once daily during deployment. Collected eggs would be removed from artificial substrates, and preserved for later laboratory analysis.

D-net. D-nets are another gear type used to collect Atlantic sturgeon eggs. The proposed D-nets are bottom-anchored drift nets 5 m long, with a D-shaped mouth 76 cm wide by 54 cm high (mouth opening, 0.41 m^2). The net is fitted with a knotless mesh and is designed to capture 3-4 mm diameter eggs, free embryos, and larvae while passing smaller particles. Egg collection materials would be removed from the river once the water temperature exceeds 15°C, or once the amount of authorized Atlantic sturgeon eggs and/or larvae has been collected; whichever comes first. A modified version of a D-net is known as an epibenthic sled, equipped with a flow meter and the same netting as described in a D-net, but is towed to collect eggs. However, only one applicant proposes to use epibenthic sleds as a collection method for ELS sampling (See application for File No. 16438).

When using either D-nets or egg mats, no more than the authorized number of eggs would be collected for any research project; eggs would be preserved and returned to the lab for identification and aging. Any excess eggs would be placed back into the river onto suitable substrate nearby in hopes of successful maturation.

Table 16: Proposed methods of capturing Atlantic sturgeon identified by applicants.							
Permit No.	Proposed Action Area	Proposed Capture Methods					
		Gill net	Trawl	Trammel Net	Egg Mat	D-Net	Other
16526	Gulf of Maine and coastal rivers; ME, NH, MA	X	X	X	X	X	X
16323	Connecticut Waters, Long Island Sound; CT, NY	X	X				
16422	Atlantic Ocean; CT, NY, NJ, DE		X				
16436	Hudson River; NY	X	X				
16438	Delaware River; DE, NJ, PA	X	X	X	X	X	X
16431	Delaware River; DE, NJ, PA	X					
16507	Delaware River, Atlantic Ocean; DE, NJ	X			X		
16547	Chesapeake Bay: James, York, Rappahannock, Potomac Rivers; MD, VA	X			X		X
16375	North Carolina Rivers & Albemarle Sound	X					
16422	South Carolina Rivers;	X	X	X	X		
16482	Georgia Rivers	X		X	X	X	
16508	Florida, Georgia Rivers; FL, GA	X					

Holding

Once captured Atlantic sturgeon are removed from capture gear, if necessary for handling a larger number of animals, they would be recovered in a floating net pen (e.g., 2 ft x 4 ft x 3 ft) or otherwise in an onboard live well. Additional net pens would be available to hold excess sturgeon and/or bycatch. Once recovered, sturgeon would be transferred to a secondary processing station (e.g., a sling) onboard for weighing, measuring, and further processing. To minimize handling stress and preserve the fish's slime coat, researchers would wear latex gloves. When in onboard holding tanks, sturgeon would be immersed in a continuous stream of water supplied by a pump-hose assembly mounted over the side of the research vessel; in some situations, dissolved oxygen (DO) would be supplemented with compressed oxygen to ensure DO concentration does not fall below acceptable levels. The total time required to complete routine handling and tagging (e.g., PIT tagging, measuring, weighing) would be approximately one minute. Atlantic sturgeon undergoing other procedures would be returned to the net pen or live well until all other sturgeon are processed. The maximum amount of time an Atlantic sturgeon would be held after removal from capture gear is two hours. However, once Atlantic sturgeon are captured, they may also be held in pound nets where authorized for up to 24 hours, if unstressed.

Measuring and Weighing

The actual method of weighing Atlantic sturgeon would vary based on the individual applicant's available equipment; however, weighing protocols would fall into two categories: spring scale or platform scale. Atlantic sturgeon weighed on a spring scale would be supported using a sling

or net. Sturgeon would be weighed on a platform scale fitted with a small waterproof cushion attached to the surface of weighing platform to fully support the fish. Morphometric measurements (e.g., total length, fork length, interorbital width) would be taken using a measuring board, solid ruler, or calipers, as appropriate.

Tissue Sampling

In order to characterize the genetic make-up and level of diversity of Atlantic sturgeon within a population, a small sample (1 cm^2) of soft fin tissue would be collected from the trailing margin of the pelvic fin using a pair of sharp sterilized scissors. Tissue samples would be preserved in individually labeled vials containing 95% ethanol. The Permit Holder must supply genetic tissue samples collected from Atlantic sturgeon for archival with the NOAA/NOS Laboratory, Charleston, South Carolina, or with other genetic specialists identified in the applicant's permit. Proper certification, identity, and chain of custody for the tissue samples would be maintained as samples are transferred.

PIT Tagging

All captured Atlantic sturgeon would be scanned with a PIT tag reader. All untagged fish (≥300mm TL) would be tagged with a PIT tag injected under the skin on the left side of the body, immediately anterior to the dorsal fin and posterior to the dorsal scutes with a hypodermic needle and syringe (e.g., 12 gauge). The most commonly used brand and size of PIT tag is a BioMark TX1411SST 134.2 kHz, 12.5x2.07mm. No juvenile fish >300 mm (TL) would be PIT tagged.

T-bar Anchor (Floy) Tagging

Another type of external tag which would be used is the T-bar anchor (Floy) tag. These tags would be inserted at the dorsal fin base in the musculature just forward and slightly downward (from the left side to the right) locking into the dorsal pterygiophores of the dorsal fin. After removing the injecting needle, the tags would be spun between the fingers and gently tugged to be locked in place. To document tag retention of these tags, recapture data would be crossed referenced with PIT tag results reported to NMFS in annual reports. No juvenile fish >300 mm (TL) would be T-bar tagged.

External Telemetry Tagging

External telemetry tags would be used to track Atlantic sturgeon movement and behavior. External transmitters would be attached to Atlantic sturgeon using the three to five minute procedure outlined in Kahn and Mohead (2010, p.30). At the discretion of the researcher, captured fish would either be anesthetized by immersion in a solution of anesthetic (e.g., MS 222 at 100 mg/l) until loss of equilibrium, or anesthetized using electronarcosis.

Pop-up Satellite Archival Tags (PSATs)

Permits 16422 and 16507 propose using Pop-up Satellite Archival Tags (PSATs) pending

availability of funding. PSATS are archival tags similar to external telemetry tags, attached externally without surgery by fastening the tag to the dorsal fin of the sturgeon by a monofilament (Erickson and Hightower 2007; Erickson *et al.* 2011). PSATs are somewhat more sophisticated than traditional telemetry tags because, in addition to recording location data of tagged animals, it can also record temperature and depth data, allowing a more comprehensive understanding of the environment the fish occupies. At a pre-programmed time, the pin attaching the tether to the PSAT will corrode, releasing the tag, allowing it to float to the surface and transmit the archived data to a satellite for retrieval. In some models, the tag transmits data via satellite in real time during deployment. PSATs are especially suited for species spending time offshore, outside where it is practical or possible to maintain an acoustic receiver array required for traditional telemetry studies.

Anesthetizing

Two primary means of anesthetization would be used: chemical anesthetization (tricaine methanesulfonate, MS-222) or electronarcosis (also known as electroanesthesia or galvanonarcosis). Certain invasive procedures, such as internal tagging, laparoscopy, and fin ray sectioning, would require anesthetization to the prescribed stage as per Kahn and Mohead (2010). Noticeably stressed Atlantic sturgeon would not be anesthetized (or undergo further invasive procedures). The majority of the applicants propose to use MS-222 as a means of anesthetizing sturgeon; those who propose to use electronarcosis are identified below.

MS-222. Each sturgeon prepared for surgery requiring anesthetization would be placed in a water bath solution containing buffered MS-222 for anesthetization (Summerfelt and Smith 1990). MS-222 concentrations of up to 150 mg/L would be used to sedate sturgeon to a proper state of anesthesia depending on the procedures being performed. The time required for anesthetization and recovery would vary depending on the prevailing water temperature and quality (Matsche 2010; Coyle *et al.* 2004). Once anesthesia is administered, sturgeon would be continuously monitored for signs of proper sedation by squeezing the tail to gauge the fish's movement and equilibrium, and checking for steady opercula movement. Just prior to performing the procedures, sturgeon would be removed from the anesthetic bath to a moist surgery rack. Respiration would be maintained by directing fresh ambient water pumped across the gills with tube inserted in the fish's mouth. After the procedures, sturgeon would be allowed to recover to normal swimming behavior in boat-side net pens or holding tanks.

Electronarcosis. Electronarcosis would be used as an alternative method for anesthetizing sturgeon in Permit No. 16526 and 16547. Using the method described by (Henyey *et al.* 2002), the researchers would use (non-pulsed) DC voltage (0.3-0.5 V/cm, 0.01 A) prescribed to immobilize fish during surgery to implant or attach sonic transmitters. In this procedure, fish would be placed in a tank with a screen anode at one end of the tank and a cathode screen at the other end. As voltage is applied quickly to the anode (1-2 sec), the subject fish would lose equilibrium, relax, and sink to the bottom. Voltage would then be decreased until the fish became immobilized but still exhibiting strong opercula movement. Fish would be supported with a cradle so only their back or ventral surface emerged from the water while work would be conducted.

Internal Telemetry Tags

To determine habitat utilization, seasonal migrations, and, in general, to track movements, Atlantic sturgeon would be fitted for internal implantation of sonic transmitter tags. There are multiple types of internal tags which would be used; VEMCO is a widely-used brand of telemetry equipment. Due to the long-distance (often coast-wide) migrations of anadromous Atlantic sturgeon, researchers desire to use compatible telemetry technology, so as to collaborate with researchers in other areas whose equipment may detect fish initially tagged elsewhere. For details and specifications on the tags used in each proposed research project, please see the respective application. Fish would be tracked passively with a VEMCO array of remote VR2W receivers positioned in the river to document movement within the river or actively tracked by field crews using mobile hydrophones. All transmitters would be limited in size to less than 2% of the fish's total weight.

Endoscopy

Boroscopy. Boroscopy is a minimally invasive method in determining the sex and maturity of Atlantic sturgeon (Moser *et al.* 2000). During the exam, the fish's head and most of the body would remain in water under a relaxed anesthetized condition, with the exam taking one to two minutes. The probe (typically 7" long x 0.16" wide) would be inserted through the genital opening and into genital tract (Kynard and Kieffer 2002). Eggs, if present, would be viewed through the wall of the genital track and staged as early stage, late stage, or potential spawners. Overall, this sampling (including standard handling and measuring), should take less than four minutes.

Laparoscopy. Laparoscopic examinations have been used extensively in fisheries research and refined for sturgeon work (Hernandez-Divers *et al.* 2004, Matsche *et al.* 2011). Laparoscopy would be used to determine the sex and reproductive health of Atlantic sturgeon. Since it is a more invasive technique than boroscope, laparoscopic procedures would only be carried out by researchers who have had proper training and experience.

Using sterile techniques and equipment, a small (~4 mm) incision would be made in the ventral body wall slightly off midline, midway between the pectoral and pelvic girdle through which a trocar would be inserted. A rigid laparoscope would then be inserted through the trocar to allow visualization of gonads. If necessary, the body cavity would be insufflated with ambient air by attaching a battery-powered air pump to the insufflation port of the trocar to increase the working space within the body cavity. Determination of sex and reproductive status would be recorded. In those instances where the sex of the fish is not readily apparent, a gonad biopsy would be taken.

Gonad Biopsy

In instances where the sex of the Atlantic sturgeon is not readily apparent following laparoscopy, gonad biopsies would be taken for histological evaluation and sex determination. A second small (~5mm) incision would be made midway between the first incision and the pectoral girdle on the lateral aspect of the body approximately 1cm dorsal to the ventral scutes. A second 5mm

trocar would then be inserted through the new incision, followed by a laparoscopic biopsy instrument to biopsy the gonad material. The sample would be approximately 5mm in size (2-3g) and would be placed in a solution (e.g., 10% neutral, buffered formalin) for preservation. Upon completion of the biopsy, the body cavity and biopsy site would again be visually assessed to ensure that there was no obvious hemorrhaged or herniated tissue. The laparoscope and the two trocars would be removed from the body and the incisions would be closed with a single suture in a cruciate pattern using suture material.

Due to the increased risk of these procedures (laparoscopy and gonad biopsy), they would only be performed in a laboratory setting. However, gonad biopsies may be performed in the field if the researcher is also implanting an acoustic tag (Kahn and Mohead 2010).

Blood Collection

Blood collection in Atlantic sturgeon would be used for the purposes of finding evidence of endocrine disruption (e.g., presence of estrogenic compounds) or sex determination. Blood would be collected from the caudal veins by inserting a hypodermic needle perpendicular to the ventral midline at a point immediately caudal to the anal fin. The needle would be slowly advanced while applying gentle negative pressure with the syringe until blood freely flows into the syringe. Once a blood sample is collected, direct pressure would be applied to the site of to ensure clotting and prevent further blood loss (Stoskopf 1993). Blood volume, needle and syringe size would be dependent on fish weight. Each blood sample would be transferred directly or by common carrier to the laboratory identified in the respective permit for diagnostic work.

Fin Ray Sectioning

Fin ray sections would typically be collected for age determination. A small section (~1 cm^2 notch), of the leading pectoral fin ray would be collected on an anesthetized fish. No other invasive procedure would be performed on fish undergoing fin ray sectioning. A sterilized hacksaw or bonesaw would be used to make two parallel cuts across the leading pectoral fin-ray, approximately 1cm deep and 1cm wide. The blade for the first cut is positioned no closer than 0.5cm from the point of articulation of the flexible pectoral base to avoid an artery at this location (Rien and Beamesderfer 1994, Rossiter *et al.* 1995, Collins 1995, Collins and Smith 1996). The second cut is made approximately 1cm distally (Everett *et al.* 2003, Fleming *et al.* 2003, Hurley *et al.* 2004, Hughes *et al.* 2005), where a pair of pliers is then used to remove the fin ray section. The sample is placed in an envelope and allowed to air-dry for several days or weeks and later it is cut into thin slices (usually about 0.5 to 2mm thickness) using a double bladed or jeweler's saw (Collins *et al.* 2008). The sections are then mounted for reading using any number of materials including clear glue, fingernail polish, cytosel, or thermoplastic cement.

Scute/Apical Hook Sampling

Sampling would involve using an orthopedic bone cutter or small saw to collect 4-10 mm clips of the apical hooks. The scute samples would be preserved by drying in envelopes. Researchers have examined the wear patterns formed on the apical spines of sturgeon scutes in early life, so

that they may determine juvenile sturgeon exposure to different water systems to determine the natal source. This proposal is based on sturgeon incorporating trace non-metabolizable rare elements into their hard tissues throughout development. The relative abundances of these elements are often unique to the geology of local watersheds (Kennedy *et al.* 1997). In some cases, hard tissues like vascular bone or keratinized structures continually resorb or shed during an individual's life span. However, other hard structures, like otoliths (ear bones), teeth or some bone formed in the dermis, are not as metabolically active once formed and can serve as records of past elemental exposure (Campana and Thorrold 2001).

Gastric Lavage

Understanding foraging habits of Atlantic sturgeon can be accomplished by using gastric lavage to evacuate the stomach contents for analysis. Researchers would be using methods described by Haley (1998), Murie and Parkyn (2000), Savoy and Benway (2004), Collins *et al.* (2008), and Kahn and Mohead (2010). Other researchers have been previously authorized to conduct gastric lavage on shortnose sturgeon with no mortalities or apparent ill effects (Savoy and Benway 2004).

Atlantic sturgeon undergoing gastric lavage would be anesthetized with MS-222 or electronarcosis to relax the alimentary canal prior to the procedure. An appropriately sized flexible polyethylene tube would be passed through the sturgeon's alimentary canal. Proper positioning of the tube in the stomach would be verified by feeling the tube from the fish's ventral surface. Stomach contents would then be removed by gently flooding the stomach cavity with water delivered from a low pressure hand pump. Food items dislodged from stomachs of sampled sturgeon would be collected with a sieve and preserved in 95% ethanol for later identification. Fish would recover within a floating net pen alongside the boat prior to release. The procedure, including anesthetizing, would take between seven to eleven minutes (Collins *et al.* 2008); no other invasive procedure would be performed on lavaged fish.

Hydroacoustic Assessment/Sonar

In recent years, remote imaging methods like side scan sonar, split beam sonar, and other similar technology have become useful tools for fisheries biologists. Dual frequency Identification Sonar (known as DIDSON), a high definition imaging sonar, was first developed for military uses, but has been applied in fisheries research (Burwen *et al.* 2010). The sonar can produce high quality images of fishes in dark or turbid water from echoes created as the fish pass through the beam. Fisheries biologists have used DIDSON to study fish behavior, monitor populations, and estimate fish size and abundance (Boswell *et al.* 2008). More recently researchers have applied DIDSON technology in sturgeon research; due to their distinct body shape, sturgeon can be distinguished from other fishes (Brundage 2006; Lori Brown, pers. Comm.). This imaging technique offers unique advantages to researchers, as it allows the opportunity to study sturgeon without capture.

II. PERMIT CONDITIONS

Researchers must comply with the following conditions related to the manner of taking:

Capture

The Permit Holder must take all necessary precautions to ensure sturgeon are not harmed during capture, including use of appropriate net mesh size and twine preventing shutting gill opercula, restricting gill netting activities, and decreasing the time of net sets.

Location (GPS), temperature, dissolved oxygen (D.O.), capture gear used (e.g., mesh size, gillnet, trammel, trawl), soak time, species captured, and mortalities must be measured and recorded (at the depth fished) each time nets are set to ensure appropriate environmental netting conditions are adhered to. This data must be made available to NMFS in annual reports or upon request.

Gear must be deployed only in waters where D.O. levels > 4.5 mg/L at the deepest depth sampled by the gear for the entire duration of deployment.

Netting may take place down to 0ºC; however, below 7ºC and above 27ºC, research procedures must be non-invasive only (e.g., PIT and Floy tag, measure, weigh, photograph, and genetic tissue clip).

Gill Netting

Gill netting for Atlantic sturgeon is regulated by environmental conditions appearing in Table below.

Table: Summary of General Gill Netting Conditions

Water Temperature (^{O}C)	Minimum D.O. Level (mg/L)	Maximum Net Set Duration (hr)
≤15	4.5	14
15 ≤ 20	4.5	4
20 ≤ 25	4.5	2
25 ≤ 28	4.5	1
>28		Cease netting until consulting with NMFS

File No. 16482 Netting Conditions
Table: Summary of gill netting conditions in Georgia waters.

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	% D.O. Saturation	Maximum Net Set Duration (hr)
0 < 15	4.0	55	10[1]
15 ≤ 20	4.0	55	4
20 ≤ 25	4.0	55	2
25 ≤ 28	4.0	55	1

Attend 10-hr deployment of gillnets in daylight hours; however, nets must be checked at least three times while set.

File No. 16375 Netting Conditions

Table: Summary of Environmental Netting Conditions in the Roanoke, Chowan and Cape Fear River Systems.

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	% D.O. Saturation	Maximum Net Set Duration (hr)
< 15	4.5	55	14[1]
< 15	4.5	55	10[2]
15 ≤ 20	4.5	55	4
20 ≤ 25	4.5	55	2
25 ≤ 28	4.5	55	1

Nets may be deployed for 14 hours overnight while unattended when water temperature and salinity are less than 15 ºC and 2ppt, respectively.
Attended 10-hr deployment of gillnets in daylight hours; however, nets must be checked at least three times while set.

Table: Summary of Seasonal Netting Conditions for Albemarle Sound (A.S.) (Other netting durations of Table 1 above apply at defined temperatures, where applicable.

Location	Season	Minimum D.O. Level (mg/L)	% D.O. Saturation	Maximum Temperature for Netting
Western A.S.[1]	Early Spring (Mar 1-May 31)	4.5	55	≤25°C
Eastern A.S.[2]	Fall/Winter (Nov 1 – Feb 28)	4.5	55	<15°C

The boundary for the western A.S. sampling area extends from the mouths of the Roanoke and Chowan Rivers to 6 km downstream.
The boundary of the eastern A.S. sampling area extends from a north-south line crossing the Albemarle Sound at Point Harbor, NC (Currituck County) to Mashoes, NC (Dare County), westward to 6 km downstream of the mouths of the Roanoke and Chowan Rivers.

File No. 16442 Netting Conditions

Table: Summary of anchored gill netting conditions in South Carolina waters.

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	% D.O. Saturation	Maximum Net Set Duration (hr)
0 < 15	4.0	55	14[1]
0 < 15	4.0	55	10[2]
15 ≤ 20	4.0	55	4
20 ≤ 25	4.0	55	2
25 ≤ 28	4.0	55	1

Unattended overnight deployment of nets is authorized in the Edisto River (Nov – March) above rkm 40.
Attended 10-hr deployment of gillnets in daylight hours; however, nets must be checked at least three times while set.

File No. 16547 Netting Conditions

Table: Anchored gill and trammel netting conditions in the Chesapeake Bay DPS.[1]

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	% D.O. Saturation	Maximum Net Set Duration (hr)
0 < 15	4.5	55	10[2]
15 < 20	4.5	55	4
20 < 25	4.5	55	2
25 ≤ 28	4.5	55	1

Anchored gill nets may only be fished for 30 minute duration before checking if fishing in the lower 20 km of a river system when water temperatures are above 15°C.

Attended 10-hr deployment in daylight hours; nets must be checked at least three times while set.

File No. 16436 Netting Conditions

Table: Summary of environmental conditions regulating gillnetting.

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	Maximum Net Set Duration (hr)
0 ≤ 15	4.5	4
15 ≤ 25	4.5	2
25 ≤ 27	4.5	1.0
27≤ 28*	4.5	0.5
>28	N.A.	Cease Netting

Artificial Substrates (collecting eggs and larvae)

The total number of eggs or larvae collected by artificial substrate must not exceed the authorized amount; any additional must be returned back to the river at the site of collection.

The eggs or larvae collected by substrate may be preserved and transported back to the lab.

Once a total authorized amount of eggs or larvae have been collected, artificial substrates must be removed from the river and sampling may be resumed the following year.

All artificial substrates must be removed from the river upon completion of this project or by the expiration date of this permit (whichever comes first).

Trawling

Trawls may be towed at an average speed up to 3.0 knots for up to 15 minutes; however, when anticipating larger catches, towing time should be minimized to limit overdue stress on catches.

A depth sounder/global positioning system should be used for monitoring trawling position to minimize disturbance of the substrate while trawling. Trawling over the same location more than once in a 24 hour period is not permitted.

If a trawl (or other gear) becomes snagged on bottom substrate or debris, it must be untangled immediately to reduce potential stress on captured animals.

Drift Gill Netting

Drift nets may be used drifting on the rising tide or in slack tide until just after high tide for 30 minutes to two hours, depending on the location and swiftness of the tide.

Drift nets must be pulled immediately if an obvious capture has been made or the gear has become snagged on substrate or bottom debris.

All drift net sets must be tended continuously due to the risk associated with gear entanglement, interaction with other protected species and/or the potential for loss of gear resulting in "ghost" nets.

Beach Seining

When drawing a beach seine's lead-lines close to shore, animals should be pooled in clearer waters with minimal turbidity.

All animals must be handled and released within 30 minutes after pooled along the shore.

Bycatch must be released unharmed and minimally handled.

Locations seined with beach seines must not be sampled more than once in a 24 hour period.

Fyke, Pound, and Hoop Nets and Other Trapping Gear

Trapping gear must be fished in accordance with state mandated requirements, and also subject to other conditions in this permit.

Trap nets must be located in areas where interactions between listed sea turtles and protected marine mammals are minimal. Specifically, these gear types may be fished in brackish waters within 20 km of river mouths between December and April when water temperature is typically less than 15^{o}C.

The maximum duration trapping gear can be fished without checking is 24 hours.

Holding

The total holding time of Atlantic sturgeon after removal from capture gear must not exceed two hours unless fish have not recovered from anesthesia.

After removal from capture gear, sturgeon must be allow to recover in floating net pens or in onboard live wells while shielding them from direct sunlight.

To accommodate larger catches, if applicable, researchers must carry secondary net pen(s) in the research vessel; overcrowded fish must be transferred to the spare net pens or else released.

When fish are onboard the research vessel for processing, the flow-through holding tank must allow for total replacement of water volume every 15 minutes. Backup oxygenation of holding tanks with compressed oxygen is necessary to ensure sturgeon do not become stressed and D.O. levels remain at or above 4.5 mg/L.

The total holding time of Atlantic sturgeon when water temperature exceeds 28ºC must never be longer than 30 minutes.

Any Atlantic sturgeon overly stressed from capture must be resuscitated and allowed to recover inside net pens or live well; prior to release, it may only be PIT and Floy tagged, weighed, measured and photographed.

Holding tanks must be cleaned and thoroughly rinsed after use; care must be taken if using cleansers with bleach due to sturgeon's sensitivity to chlorine.

Handling

Onboard handling of sturgeon should be minimized, keeping fish in water as much as possible and supporting with a sling or net.

The total handling time, including onboard research procedures, must not exceed 15 minutes (not including recovery from anesthesia or a stressed condition).

Atlantic sturgeon (and bycatch) must be allowed to recover before they are released to ensure full recovery; and it is recommended, if possible, they be treated with an electrolyte bath (e.g., salt) prior to release to help reduce stress and restore slime coat.

Prior to release, sturgeon should be examined and, if necessary, recovered by holding fish upright and immersed in river water, gently moving the fish front to back, aiding freshwater passage over the gills to stimulate it. The fish should be released only when showing signs of vigor and able to swim away under its own power. A spotter should watch the fish, making sure it stays submerged and does not need additional recovery.

Genetic Tissue Sampling

Care must be used when collecting genetic tissue samples from the soft fin rays of sturgeon (e.g. pelvic fins). Instruments should be changed or disinfected and gloves changed between each fish sampled to avoid possible disease transmission or cross contamination of genetic material.

Submission and archival of genetic tissue samples must be coordinated with Julie Carter (or the current designated PI on NOS Permit No. 13599) at the NOAA-NOS tissue archive in Charleston, SC (843) 762-8547. A *Biological Sample Certification, Identification and Chain of Custody Form* must accompany shipments of genetic tissue samples to the NOAA-NOS archive in Charleston, South Carolina. Samples must be submitted between six and twelve months after collection, or when periodically solicited by the Permits Division.

A *Field Collection Report* should also accompany multiple genetic tissue samples (hard copy or spreadsheet) when shipping to the archive.

The Permit Holder may not transfer biological samples to anyone not listed in the application without obtaining prior written approval from NMFS. Any such transfer will be subject to such conditions as NMFS deems appropriate.

The terms and conditions concerning samples collected under this authorization will remain in effect as long as the material taken is maintained under the authority and responsibility of the Permit Holder.

Tagging Conditions

PIT tags must be used to individually identify all captured fish not previously tagged. Prior to placement of PIT tags, the entire dorsal surface of each fish must be scanned with a waterproof PIT tag reader and visually inspected to ensure detection of fish tagged in other studies. Previously PIT-tagged fish must not be retagged.

Researchers must not insert PIT tags or perform other surgical procedures on juvenile Atlantic sturgeon less than 250 mm in length.

PIT tags should be injected in the left, dorsal musculature just anterior to the dorsal fin with the copper antenna oriented up for maximum signal strength and scanned after implantation to ensure proper tag function.

When inserting numbered Floy tags, tags must be anchored in the dorsal fin musculature base by inserting forward and slightly downward from the left side to the right through the dorsal pterygiophores.

The rate of tag retention (e.g., PIT tag, Floy tag, Dart tag, Carlin tag, telemetry tags) and the condition of fish at the site of tag injection should be documented during the study and results reported to the Permits Division in annual and final reports.

The total weight of all tags used to mark fish must not exceed 2% of the sturgeon's total body weight unless otherwise authorized by the Permits Division.

Internal and External Telemetry Tags

Surgical implantation of internal tags must only be attempted when fish are in excellent condition, and must not be attempted on pre-spawning fish in spring or fish on the spawning ground.

During surgical procedures, instruments must be sterilized or changed between uses.

To ensure proper closure of surgical incisions, a single interrupted suturing technique should be applied.

Surgical implantation of internal tags or attachment of external sonic tags must not occur when water temperatures exceed 27°C or are less than 7°C.

To ensure proper closure of surgical incisions, a single, uninterrupted suturing technique should be applied.

Pop-off satellite tags are authorized by attaching the tag externally without anesthesia to the sturgeon's dorsal fin using a monofilament tether.

Researchers are required to document in annual and final reports any information on telemetry tag adaptation and retention by manually or passively tracking individual fish (using boats and/or passive receiver arrays), and recording swimming behavior, periods between detections, and numbers of un-relocated individuals after tagging. Additionally, information on the healing rates of incisions of recaptured fish should be documented from recaptured fish.

Anesthetization

Researchers performing anesthesia on sturgeon must have first received supervised training on shortnose sturgeon or another surrogate species before doing so. The Permit Holder must report this training to the Permits Division prior to the activity.

Only non-stressed animals in excellent health should be anesthetized.

To avoid injury while anesthetizing sturgeon in bath treatments, researchers must use restraint (e.g., netting) to prevent animals from jumping or falling out of the container.

When inducing anesthesia on Atlantic sturgeon, researchers must observe fish closely to establish the proper level of narcosis.

While performing a surgical procedure, if sudden reflex reaction from an anesthetized fish is encountered, the Researcher must stop the procedure and evaluate the level of anesthesia before proceeding.

Researchers must observe Atlantic sturgeon closely during recovery from anesthesia, ensuring full recovery prior to release.

MS-222

Researchers may use MS-222 at concentrations up to 150 mg/L when anesthetizing Atlantic sturgeon to implant sonic transmitters; such solutions must be made fresh daily.

Prior to anesthetizing Atlantic sturgeon with MS-222, researchers must saturate the solution with dissolved oxygen and buffer it to a neutral pH with sodium bicarbonate.

All researchers are required to wear protective clothing, gloves, and goggles when handling MS-222 powder.

MS-222 solutions must be disposed of by using state adopted procedures.

Electronarcosis

NMFS authorizes electronarcosis for inducing anesthesia on Atlantic sturgeon using low voltage direct current as described by Henyey *et al.* (2002). NMFS requires all results using electronarcosis be included in annual and final reports.

Researchers performing electronarcosis must have first received supervised training from a properly permitted individual using either wild or captive Atlantic sturgeon, or another surrogate sturgeon species.

Gastric Lavage

Researchers performing gastric lavage on Atlantic sturgeon must first receive supervised training on Atlantic sturgeon or another surrogate sturgeon species. The Responsible Party or PI must document training to NMFS prior to the activity.

To avoid injury to shortnose sturgeon during gastric lavage, researchers must take precaution passing lavage tubes into position through the alimentary canal and into the fish's stomach.

Prior to gastric lavage, researchers must anesthetize sturgeon with MS-222 to relax the alimentary canal and provide ease of penetration by the tubing to the proper position in the gut.

Researchers may carry out gastric lavage on shortnose sturgeon averaging between 250 mm and 350 mm (FL) using flexible tubing up to 1.90mm outside diameter (O.D.); sturgeon between 350mm and 1,250 mm may be lavaged with tubing up to 4.06 mm (O.D); and sturgeon above 1250 mm may be lavaged with flexible tubing up to 10.15 mm O.D.

No other research method requiring anesthesia, (i.e., fin ray sampling, laparoscopy or sonic tag implantation), may be conducted on the same fish selected for gastric lavage.

Gill Biopsy, Gonad Biopsy, Fin Ray Sampling, Apical Spine Sampling and Blood Collection

Blood and biopsy samples may be sent to the cooperating laboratories for analysis.

Blood and biopsy samples not consumed during testing must be properly disposed of immediately after all testing is completed.

Care must be used when collecting biological samples. Instruments must be disinfected or changed and gloves must be changed between sampling each fish to avoid possible disease transmission or cross contamination of genetic material.

Only designated CIs are authorized for blood sampling procedures. Blood samples may be analyzed by the Permit Holder or sent to the cooperating laboratories listed in Condition C.1 for analysis.

Blood samples not consumed during testing must be destroyed and properly disposed of after all testing is completed.

Apical spines of dorsal scutes may be taken from Atlantic sturgeon for river of origin determination. Spines may be collected by removing 4 -10 mm clips using an orthopedic bone cutter or small saw.

Fin ray section samples (1-mm x 1-mm clip) are authorized to be collected using sterilized snipping pliers or bone saws and scalpels from the pectoral fin ray while fish are under light anesthesia (See Kahn and Mohead 2010, p42).

Detailed records should be kept on the recovery and other responses from fin-ray removal, as well the condition and health of recaptured sturgeon. This information must be reported to NMFS in annual reports.

Apical spines and fin ray section samples may be analyzed by the Permit Holder, stored for future analyses, or sent to cooperating laboratories listed in Condition C.1 for analysis.

The Permit Holder is ultimately responsible for compliance with this permit and applicable regulations related to the samples unless the samples are permanently transferred according to NMFS regulations governing the taking, importing, and exporting of endangered and threatened species (50 CFR 222.308).

The Permit Holder must receive written approval from the Permits Division to use samples for purposes not related to the permitted objectives.

Samples must be maintained according to accepted curatorial standards and must be labeled with a unique identifier (e.g., alphanumeric code) that is connected to on-site records with information identifying the:

-species and, where known, age and sex
-date of collection, acquisition, or import
-type of sample (*e.g.*, blood, skin, bone)
-origin (*i.e.*, where collected or imported from)

The Permit Holder may request approval of Authorized Recipients for analysis and curation of samples related to the permit objectives by submitting a written request to the Permits Division specifying:

-the name and affiliation of the recipient.
-the address of the recipient.
-the types of samples to be sent (species, tissue type).
-whether the disposition is analysis or curation.

Sample recipients must have written authorization from a NMFS Regional Office prior to permanent transfer of samples and transfers for purposes not related to the objectives of this permit.

Samples cannot be bought or sold, including parts transferred through written authorization by a NMFS Regional Office.

In general, the Permit Holder may not transfer biological samples to anyone not listed in the application without obtaining prior written approval from NMFS. Any such transfer will be subject to such conditions as NMFS deems appropriate.

The terms and conditions concerning biological samples collected under this authorization will remain in effect during and after the permitted period as long as the material taken is maintained under the authority and responsibility of the Permit Holder.

Endoscopic Examination (Borescope)

Borescopy for identifying sex/maturity is authorized for Atlantic sturgeon ($\geq$70 cm TL), excluding those releasing eggs or sperm while handling.

Prior to an individual researcher performing unassisted borescopy, s/he must have had first received supervised training from a properly permitted individual using either wild or captive Atlantic sturgeon, or another surrogate sturgeon species.

Laparoscopic/Borescopic Examination

Researchers performing laparoscopy or borescopy on Atlantic sturgeon must have first received supervised training on Atlantic sturgeon or another surrogate species before doing so. The Responsible Party or PI must report this training to NMFS prior to the activity.

Should uncontrolled hemorrhaging occur while performing laparoscopy, the procedure should be stopped and the bleeding stabilized before deciding to proceed, or else stopping the procedure and recovering the animal for release.

Marine Mammals

Nets must not be deployed when marine mammals are observed within the vicinity of the research.

If sighted, marine mammals must be allowed to either leave or pass through the area safely before net setting is initiated.

Should any marine mammal enter the research area after the nets have been deployed, the leadline should be raised and dropped in an attempt to make marine mammals in the vicinity aware of the net.

If marine mammals remain within the vicinity of the research area or approach the gear, nets must be removed.

Additionally, in all boating activities, researchers are advised to keep a close watch for marine mammals to avoid harassment or interaction and also to review the NMFS Guidelines for Viewing Marine Mammals (http://www.nmfs.noaa.gov/pr/education/regional.htm).

Interactions with marine mammals should be documented with any pertinent details (species, type of interaction, location, date, size, water and air temperature, and photographs, if possible). Researchers should report any marine mammal interaction within 48 hours to the Chief, Permits Division and/or the permit analyst at 301-427-8401.

Sea Turtles

Researchers must attempt to avoid sea turtle interactions by sampling in waters below 18°C, when turtles are typically absent.

(The following conditions were suggested by the NMFS Science Centers as a precautionary measure addressing how researchers would handle/resuscitate a sea turtle if one were incidentally captured.)

If a sea turtle were incidentally captured during netting, the Permit Holder, Principal Investigator, Co-investigator(s), or Research Assistant(s) acting on the Permit Holder's behalf must use care when handling a live turtle to minimize any possible injury; and appropriate resuscitation techniques must be used on any comatose turtle prior to returning it to the water. All turtles must be handled according to procedures specified in 50 CFR 223.206(d)(1)(i).

Interactions with sea turtles should be documented with any pertinent detail (species, type of interaction, location, date, size, water & air temp, any obvious patterns and photos if possible).

Researchers should report any sea turtle interaction within 48 hours to the Chief, Permits Division and/or the permit analyst at 301-427-8401.

Shortnose Sturgeon

If a shortnose sturgeon is incidentally captured, it should be PIT tagged (according to the procedures indicated for Atlantic sturgeon), genetically sampled (1 cm^2 fin clip), and released. NMFS also requests all other netting protocols and research conditions protective of Atlantic sturgeon be used by researchers to ensure survival of shortnose sturgeon during research activities.

NMFS requests all shortnose sturgeon interactions are reported to Lynn Lankshear, (Lynn.Lankshear@noaa.gov or 978-281-9300 x 6535). If dead specimens are collected, this report should be documented by completing the sturgeon salvage form. Specimens or body parts of dead shortnose sturgeon should be preserved — preferably on ice or refrigeration — until sampling and disposal procedures are discussed with NMFS.

Specific Netting Conditions Protective of Atlantic Salmon

Protective of Atlantic salmon in the Kennebec River, gill nets must not be set within 0.5 miles upstream or downstream of the confluences of the Kennebec River and Bond Brook, and 0.5 miles below Lockwood Dam.

Researchers must avoid fishing in documented locations of the Kennebec complex where Atlantic salmon have been encountered in the past (i.e., Sand Island @ 43.914465,-69.727821; Pine Island @ 43.914465,-69.727821; and Fort Halifax Park @ 44.54482,-69.627271).

Protective of Atlantic salmon in the Penobscot River, nets must not be set within 0.5 miles upstream or downstream of the confluences of the Penobscot River and Cove Brook, Kenduskeag River, Ducktrap River, or Meadow Brook.

Researchers must avoid fishing in documented locations of the Penobscot River where Atlantic salmon have been encountered in the past (i.e., in shallower, non-channel waters of Oak Point Cove @44.667005,-68.822994; and Graham Station @44.821459,-68.708721).

In GOM rivers with runs of Atlantic salmon, gillnets with ≥6-in mesh may be fished in main channels of rivers and bays of the action area at depths greater than 20 feet at low tide. Nets may also be fished in areas characterized as “mudflats,” off main channels in waters less than 10 feet at low tide.

Should an Atlantic salmon be taken incidentally during netting, researchers must suspend operations immediately and notify NOAA Fisheries Northeast Region Protected Resources Division, Jeff Murphy at (207) 866-7379 (Jeff.Murphy@noaa.gov) and the Chief, Permits Division, Office of Protected Resources at (301) 713-2289 within 48 hours of any capture of an Atlantic salmon.

An incidentally captured Atlantic salmon must be released back to the river alive; it must be cut free from the net mesh, held in the water to the maximum extent practical.

Bycatch

All non-ESA listed incidentally captured species (e.g., fishes) must be released alive as soon as possible.

Collecting Eggs/Larvae with Artificial Substrates (Egg Mats) or D-nets

Deployment of artificial substrates and D-nets is authorized for collecting Atlantic sturgeon eggs and larvae between March and December, the optimal timing for deployment determined by researchers.

D-nets may be set in suspected spawning areas for a maximum duration of three (3) hour intervals before checking.

Egg mats should be checked at least twice weekly, or more frequently if circumstances allow.

No more egg mats should be fished than necessary. If the researcher is unsure of the number of pads required to identify spawning areas and success, no more than 150 pads should be fished at once across several sites.

A subset of authorized eggs collected with egg mats (proportion determined by the researcher) may be preserved in 95% ETOH and transported to a laboratory for species verification; the remainder must be returned to the river at the site of collection.

If it is not necessary to remove the eggs from the artificial substrate, it may be returned to the river bottom allowing the eggs to incubate and hatch before being removed.

All artificial substrates and D-nets must be removed from rivers once water temperatures exceed 25ºC, or is less than 0ºC, or the authorized numbers of Atlantic sturgeon eggs and/or larvae have been collected, whichever comes first.

III. APPROACH TO THE ASSESSMENT

NOAA Fisheries Service approaches its section 7 analyses of research permits through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The results of this step define the action area for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our exposure analyses). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our response analyses).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our risk analyses). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of species depends on the fate of the populations that comprise them, the continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (*see* Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a necessary condition for reductions in a population's viability, which is itself a necessary condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (*e.g.*, Anderson 2000, Mills and Beatty 1979, Brandon 1978, Stearns 1992). As a result, if we conclude that listed plants or animals are not likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals are a necessary condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always sufficient to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established

in the *Environmental Baseline* and Status of Listed Resources sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always sufficient to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the Status of the Species section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the evidence available to us. This evidence might consist of monitoring reports submitted by past and present permit holders; reports from NMFS Science Centers; reports prepared by natural resource agencies in States, and other countries; reports from foreign and domestic non-governmental organizations involved in marine conservation issues; the information provided by PR1 when it initiates formal consultation; information from commercial interests; and the general scientific literature.

During each consultation, we conduct electronic searches of the general scientific literature using search engines such as Zoorecord, Biosis, ArticleFirst, FirstSearch, Google Scholar, JSTOR, Science Direct, and SpringerLink. We supplement these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically try to identify data or other information that supports a particular conclusion (for example, a study that suggests Atlantic sturgeon will exhibit a particular response to dissolved oxygen concentrations) as well as contradicting data. When data are equivocal, or in the face of substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely.

We rank the results of these searches based on the quality of their study design, sample sizes, level of scrutiny prior to and during publication, and study results. Carefully-designed field experiments (for example, experiments that control potentially confounding variables) are rated higher than field experiments that are not designed to control those variables. Carefully-designed field experiments are generally ranked higher than computer simulations. Studies that produce large sample sizes with small variances are generally ranked higher than studies with small sample sizes or large variances.

IV. DESCRIPTION OF THE ACTION AREA

Proposed research activities on Atlantic sturgeon DPSs would take place in river systems across the U.S. range of the species, extending from the coastal waters of Maine to the tidal rivers of northern Florida. The action area includes the Atlantic Ocean (state waters), the Gulf of Maine (including coastal river systems in Maine, New Hampshire, and Massachusetts), coastal rivers of Connecticut, Long Island Sound, the Hudson River estuary, the Delaware River, the Chesapeake

Bay and its tributaries, North Carolina rivers, South Carolina Rivers, Georgia rivers, and the Nassau and St. Johns Rivers in Florida. Detailed maps of the action area are presented in the Appendix.

V. STATUS OF THE SPECIES /CRITICAL HABITAT

NMFS has determined that the action being considered in this Opinion may affect the following species that are protected under the ESA:

Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Atlantic salmon	*Salmo salar*	Endangered
Gulf of Maine DPS		
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	
Gulf of Maine DPS		Threatened
New York Bight DPS		Endangered
Chesapeake Bay DPS		Endangered
Carolina DPS		Endangered
South Atlantic DPS		Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Loggerhead sea turtle	*Caretta caretta*	
Northwest Atlantic Ocean DPS		Threatened
Green sea turtle	*Chelonia mydas*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Hawksbill sea turtle	*Eretmochelys imbricate*	Endangered
Smalltooth sawfish	*Pristis pectinata*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered

Listed Resources Not Considered Further in this Opinion

Atlantic salmon
PR1 would instigate the following measures for minimizing impacts on Atlantic salmon from Atlantic sturgeon research in the GOM DPS geographic area. These minimization measures appear as conditions in permit 16526.

Kennebec River Complex
Evidence from telemetry studies indicates adult salmon tend to swim in the upper water column at mean depths 3.7–4.0 m and tend to congregate in known areas from year to year (Gowans *et al.* 1999; and Sturlaugsson 1995). Thus, in order to minimize capture of Atlantic salmon in the Kennebec complex action area of the GOM where interactions with Atlantic salmon might occur, the applicant must adhere to the following specific conditions:

- Avoid fishing in documented locations of the Kennebec complex where Atlantic salmon have been encountered in the past (i.e., Sand Island @ < 43.914465,-69.727821>; Pine Island @ < 43.914465,-69.727821>; and Fort Halifax Park @ <44.54482,-69.627271>).
- Avoid fishing within 0.5 miles upstream or downstream of the confluences of the Kennebec River and Bond Brook, and also fish at least 0.5 miles below Lockwood Dam;
- Fish gillnets in main channels of rivers and bays of the Kennebec Complex at depths greater than 20 feet at low tide. Nets may also be fished in areas characterized as "mudflats," off main channels in waters less than 10 feet at low tide;
- Fish according to NMFS's netting guidelines protective of both sturgeon and salmon; however, researchers would continuously monitor nets, limiting net sets typically to one hour before checking, and also removing any captured animal at time of capture;
- Deploy D-nets by anchoring on the deepest channel bottoms downstream of known or suspected sturgeon spawning areas to avoid drifting salmon smolt near the surface.

Additionally, to further reduce potential for harming Atlantic salmon in the Kennebec complex, the applicant would adhere to other conservative measures, including: (1) constantly monitoring nets, (2) removing animals from nets as soon as capture is recognized; and (3) deployed nets would be checked every six hours between 0 and 15^{o}C; (4) nets would be checked hourly at water temperature between 15and 20^{o} C; and every 30 minutes between 20 and 26^{o}C.

Penobscot River

The permit conditions for the Penobscot River would include these specific conditions:

- Set nets beyond 0.5 miles upstream or downstream of the confluences of the Penobscot River and Cove Brook, Kenduskeag River, Ducktrap River, or Meadow Brook;
- Fish only 12" mesh from the Waterworks at the site of the former Bangor Dam upstream to the Veazie Dam.
- Fish six or 12 inch (stretched gill or trammel) nets in main channels and bays of the Penobscot River and estuary anchored at depths greater than 20 feet at low tide. Nets may also be fished in areas characterized as mudflats, off main channels in waters less than 10 feet at low tide.
- Avoid fishing in documented locations of the Penobscot River where Atlantic salmon have been encountered in the past (i.e., in shallower, non-channel waters of Oak Point Cove @44.667005,-68.822994; and Graham Station @44.821459,-68.7087215);
- Deploy D-nets by anchoring on the deepest channel bottoms downstream of known or suspected sturgeon spawning areas to avoid drifting salmon smolt near the surface.

Additionally, other conservative measures protective of salmon in the Penobscot River would be employed. These would include: (1) constantly monitoring nets; (2) removing animals from nets as soon as capture is recognized; (3) fishing no more than ten hours when water temperatures are less than 15^{o}C; (4) using up to three hour intervals when water temperatures are between 15 and 20 ^{o}C; (5) using up to two hour intervals when water temperatures are between 20 and 25 ^{o}C; (6) and checking nets every hour at water temperatures between 25 and 28 ^{o}C.

We concluded, based on the methods proposed by researchers in the GOM, and their resulting limited interactions with Atlantic salmon over an extended period of time, adherence to the above measures would likely minimize potential future salmon interactions; and thus, no incidental capture or mortality for Atlantic salmon will be authorized. NMFS contacted the NMFS Northeast Region (Orono, ME) requesting Atlantic salmon specialists analyze the potential impacts of research proposed in the action areas of File 16526 on GOM DPS Atlantic salmon. They concurred with our conclusions by email (received October 2011), stating that "overall, NMFS does not expect the proposed Atlantic sturgeon sampling effort in the GOM would result in increased interactions with Atlantic salmon so long as the recommended gear modifications and proposed area restrictions with protective measures were adhered to." Therefore, Atlantic salmon are not considered further in this Opinion.

Smalltooth sawfish

Historic capture records of smalltooth sawfish are within the U.S. range from Texas to New York, although peninsular Florida has historically been the U.S. region with the largest number of recorded captures and likely represents the core of the historic range (NMFS 2000). Recent records indicate there is a resident reproducing population of smalltooth sawfish in south and southwest Florida from Charlotte Harbor through the Dry Tortugas which also serves as the last U.S. stronghold for the species (Seitz and Poulakis, 2002; Poulakis and Seitz, 2004; Simpfendorfer and Wiley, 2005). Further, water temperatures no lower than 16-18 °C and the availability of appropriate coastal habitat serve as the major environmental constraints limit the northern movements of smalltooth sawfish northward.

Most recent historical records of this species from northern Florida and north occuring rarely in the action area (permit 16482 and 16508) have been reported during spring and summer periods (May to August) when inshore waters reach higher temperatures. Animals found occur typically as large adults (over 10 feet), likely representing seasonal migrants, wanderers, or colonizers from an historic Florida core population(s) to the south rather than being members of a continuous, even-density population (Bigelow and Schroeder, 1953).

Given the species' effective range and reported limited distribution in northwest Florida, and given measures incorporated into the researchers' methodology, NMFS believes that these factors are significant enough to reduce adverse effects to the smalltooth sawfish to the level that they are discountable. Therefore this species is not considered further in this Opinion.

Listed Whales

ESA endangered blue, fin, humpback, North Atlantic right, sei, and sperm whales could potentially occur within each of the action areas and could be subject to harassment and/or harm from boat strikes or entanglement in netting gear as a result of the proposed activities. Critical habitat has also been designated for the endangered North Atlantic right whale off the states of Georgia and Florida (59 FR 28793; June 3, 1994). However, each of these whale species are typically located further offshore in deeper waters than the areas targeted by the proposed research. It is highly unlikely that they would be encountered during sampling activities performed by the research applicants. Consequently, we concluded that these species are unlikely to be exposed to the effects of the proposed actions and thus any potential threats are

discountable. Therefore, the proposed actions are not likely to adversely affect any of these listed cetaceans and these species will not be considered further in this Opinion.

Atlantic salmon Critical Habitat

No critical habitat has been designated for Atlantic sturgeon; therefore, none will be affected by the proposed action. However, critical habitat does exist for Atlantic salmon within the action area. Coincident with a June 19, 2009 endangered ESA listing for GOM distinct population segment (DPS) Atlantic salmon, NMFS and the USFWS designated critical habitat (74 FR 29300; June 19, 2009). The new listing was expanded to include all anadromous Atlantic salmon streams whose freshwater range occurs in watersheds from the Androscoggin River northward along the Maine coast northeastward to the Dennys River, and wherever these fish occur in the estuarine and marine environment. Therefore, proposed research in Maine rivers would occur in newly delineated Atlantic salmon critical habitat.

Critical habitat is defined as specific areas containing physical and biological features essential to the conservation of the species. Primary Constituent Elements (PCEs) for critical habitat identified for the GOM DPS Atlantic salmon include factors essential for the conservation of the species. Within the occupied range of the Gulf of Maine DPS, Atlantic salmon PCEs are regarded as providing: sites for spawning and incubation, sites for juvenile rearing, and sites for unobstructed migration.

The critical habitat PCE relevant to Permit 16526 focuses on providing unobstructed migratory pathways for Atlantic salmon adults and smolts. Thus, specific PCE factors and conclusions potentially impacting critical habitat for salmon under the proposed action were found to be as follows:

(1) Freshwater and estuary migratory sites free from physical and biological barriers delaying or preventing access of adult salmon seeking spawning grounds needed to support recovered populations: This factor is related to adult Atlantic salmon returning to their natal rivers or streams requiring migration sites free from barriers obstructing or delaying passage to reach their spawning grounds at the proper time for effective spawning (Bjornn and Reiser 1991). Migration sites free from physical and biological barriers are essential to the conservation of the species because without them, adult Atlantic salmon adults would not be able to access spawning grounds needed for egg deposition and embryo development. The extent adult salmon migration would be blocked by the proposed fisheries research proposals is relevant to the impacts on critical habitat.

We examined the potential for the research to obstruct migratory pathways between adjacent riverine and estuarine critical habitat units. We concluded that the research nets present a very small barrier in place relative to the size of the remaining river area available for salmon migration. Nets are checked at minimum each hour when in use, or immediately if an animal is captured, and is therefore not a permanent structure. Moreover, gillnetting employed by researchers has been conditioned in current permits to successfully limit interaction within the Atlantic salmon migratory pathways as evidenced by numbers of salmon netted historically. Consequently, we do not believe proposed netting in the project modifications would affect the ability of the critical habitat to provide unobstructed migratory pathways for adult Atlantic salmon.

(2) **Freshwater and estuary migration sites free from physical and biological barriers delaying or preventing emigration of smolts to the marine environment:** This feature is essential to the conservation of the species because Atlantic salmon smolts require an open migration corridor from their juvenile rearing habitat to the marine environment.

D-shaped ichthyoplankton nets (D-nets) are described as gear for collecting Atlantic sturgeon eggs and larvae in potential sturgeon spawning areas in the Kennebec, Androscoggin and Penobscot River systems (Kieffer and Kynard 1996). D-nets or egg mats could potentially serve as a physical barrier for the emigration of Atlantic salmon smolt. D-nets and egg mats would be deployed and anchored in a row along the deepest channel bottoms near spawning sites 100 to 300 meters downstream of known or suspected sturgeon spawning areas. These nets would soak for no more than 3 hours at a time before being raised and examined for eggs or larvae before being re-deployed. However, because D-nets and egg mats would be anchored to the river bottom, drifting smolt near the surface would not be exposed to likely capture. Moreover, as there have been no smolts captured in the Kennebec and Penobscot Rivers while using D-nets, we concluded that D-nets would not affect the ability of the critical habitat to provide an unobstructed downstream migratory pathway for Atlantic salmon smolts.

(3) **Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation:** Adult Atlantic salmon and Atlantic salmon smolts interact with other diadromous species indirectly while migrating. Adult and smolt migration through the estuary often coincides with the presence of alewives (*Alosa* spp.), American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), and striped bass (*Morone saxatilis*). The abundance of diadromous species present during adult migration may serve as an alternative prey source for seals, porpoises and otters (Saunders *et al.* 2006). For example, as Atlantic salmon smolts pass through the estuary during migration from their freshwater rearing sites to the marine environment, they experience high levels of predation. These features are essential to the conservation of the species because without highly prolific abundant alternate prey species such as alewives and shad, the less prolific Atlantic salmon would likely become a preferred prey species.

We examined whether proposed research activities would appreciably reduce the abundance of riverine or estuarine buffer prey for Atlantic salmon adults or smolts within the migratory critical habitat. We examined whether prey species structure in action area would be affected by the proposed action, but concluded, based on the limited amount of by-catch of the above species captured by researchers in the past, and the fact that virtually all of the by-catch reported has been reported released during sampling, there would be minimal impacts to associated buffer prey organisms in the freshwater and estuarine critical habitat. Thus, we concluded that the ability of the critical habitat providing fish communities as protective buffers against predation, does not obstruct migratory pathways for adult or juvenile Atlantic salmon in either action.

After analyzing the specific PCEs above that are relevant to the proposed action, we do not believe that Atlantic salmon GOM DPS critical habitat will be affected by the proposed action. Therefore, we do not consider it further in this Opinion.

STATUS OF THE SPECIES CONSIDERED IN THIS OPINION

Green sea turtle

Distribution. Green sea turtles have a circumglobal distribution, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters.

Population designation. Populations are distinguished generally by ocean basin and more specifically by nesting location (Table 17).

Based upon genetic differences, two or three distinct regional clades may exist in the Pacific: western Pacific and South Pacific islands, eastern Pacific, and central Pacific, including the rookery at French Frigate Shoals, Hawaii (Dutton and Balazs In review; Dutton *et al.* 1996). In the eastern Pacific, green sea turtles forage from San Diego Bay, California to Mejillones, Chile. Individuals along the southern foraging area originate from Galapagos Islands nesting beaches, while those in the Gulf of California originate primarily from Michoacán. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003).

Table 17. Atlantic Ocean locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF), annual nests (AN), annual egg production (EP), and annual egg harvest (EH).

Location	Most recent abundance	Reference
Western Atlantic Ocean		
Tortuguero, Costa Rica	17,402-37,290 AF	(Troëng and Rankin 2005)
Aves Island, Venezuela	335-443 AF	(Vera 2007)
Galibi Reserve, Suriname	1,803 AF	(Weijerman *et al.* 1998)
Isla Trindade, Brazil	1,500-2,000 AF	(Moreira and Bjorndal 2006)
Central Atlantic Ocean		
Ascension Island, UK	3,500 AF	(Broderick *et al.* 2006)
Eastern Atlantic Ocean		
Poilao Island, Guinea-Bissau	7,000-29,000 AN	(Catry *et al.* 2009)
Bioko Island, Equatorial Guinea	1,255-1,681 AN	(Tomas *et al.* 1999)

Growth and reproduction. Most green sea turtles exhibit particularly slow growth rates, which have been attributed to their largely plant-eating diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka *et al.* 2004), and density of turtles in foraging areas (Balazs and Chaloupka 2004; Bjorndal *et al.* 2000; Seminoff *et al.* 2002b). If individuals do not feed sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark *et al.* 2009). In general, there is a tendency for green sea turtles to exhibit monotonic growth (declining growth rate with size) in the Atlantic and non-monotonic growth (growth spurt in mid size classes) in the Pacific, although this is not always

the case (Balazs and Chaloupka 2004; Chaloupka and Musick 1997; Seminoff *et al.* 2002b). It is estimated that green sea turtles reach a maximum size just under 100 cm in carapace length (Tanaka 2009). A female-bias has been identified from studies of green sea turtles (Wibbels 2003).

Consistent with slow growth, age-to-maturity for green sea turtles appears to be the longest of any sea turtle species and ranges from ~20-40 years or more (Chaloupka *et al.* 2004; Chaloupka and Musick 1997; Hirth 1997; Limpus and Chaloupka 1997; Seminoff *et al.* 2002b; Zug *et al.* 2002; Zug and Glor 1998)(Balazs 1982, Frazer and Ehrhart 1985). Estimates of reproductive longevity range from 17 to 23 years (Carr *et al.* 1978; Chaloupka *et al.* 2004; Fitzsimmons *et al.* 1995). Considering that mean duration between females returning to nest ranges from 2 to 5 years (Hirth 1997), these reproductive longevity estimates suggest that a female may nest 3 to 11 seasons over the course of her life. Each female deposits 1-7 clutches (usually 2-3) during the breeding season at 12-14 day intervals. Mean clutch size is highly variable among populations, but averages 110-115 eggs/nest. Females usually have 2-4 or more years between breeding seasons, whereas males may mate every year (Balazs 1983). Based on reasonable means of three nests per season and 100 eggs per nest (Hirth 1997), a female may deposit 9 to 33 clutches, or about 900 to 3,300 eggs, during her lifetime. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).
Once hatched, sea turtles emerge and orient towards a light source, such as light shining off the ocean. They enter the sea in a "frenzy" of swimming activity, which decreases rapidly in the first few hours and gradually over the first several weeks (Ischer *et al.* 2009; Okuyama *et al.* 2009). Factors in the ocean environment have a major influence on reproduction (Chaloupka 2001; Limpus and Nicholls 1988; Solow *et al.* 2002). It is also apparent that during years of heavy nesting activity, density dependent factors (beach crowding and digging up of eggs by nesting females) may impact hatchling production (Tiwari *et al.* 2005; Tiwari *et al.* 2006). Precipitation, proximity to the high tide line, and nest depth can also significantly affect nesting success (Cheng *et al.* 2009). Precipitation can also be significant in sex determination, with greater nest moisture resulting in a higher proportion of males (Leblanc and Wibbels 2009).
Green sea turtles often return to the same foraging areas following nesting migrations (Broderick *et al.* 2006; Godley *et al.* 2002). Once there, they move within specific areas, or home ranges, where they routinely visit specific localities to forage and rest (Godley *et al.* 2003; Makowski *et al.* 2006; Seminoff and Jones 2006; Seminoff *et al.* 2002a; Taquet *et al.* 2006). It is also apparent that some green sea turtles remain in pelagic habitats for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier *et al.* 2003).

In general, survivorship tends to be lower for juveniles and sub-adults than for adults. Adult survivorship has been calculated to range from 0.82-0.97 versus 0.58-0.89 for juveniles (Chaloupka and Limpus 2005; Seminoff *et al.* 2003; Troëng and Chaloupka 2007), with lower values coinciding with areas of human impact on green sea turtles and their habitats (Bjorndal *et al.* 2003; Campbell and Lagueux 2005).

Migration and movement. Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. After departing as hatchlings and residing in a variety

of marine habitats for 40 or more years (Limpus and Chaloupka 1997), green sea turtles make their way back to the same beach from which they hatched (Carr *et al.* 1978; Meylan *et al.* 1990). At approximately 20- to 25-cm carapace length, juveniles leave pelagic habitats and enter benthic foraging areas (Bjorndal 1997). Green sea turtles spend the majority of their lives in coastal foraging grounds. These areas include both open coastline and protected bays and lagoons. While in these areas, green sea turtles rely on marine algae and seagrass as their primary dietary constituents, although some populations also forage heavily on invertebrates. There is some evidence that individuals move from shallow seagrass beds during the day to deeper areas at night (Hazel 2009). However, avoidance of areas of greater than 10 m when moderate depths of 5-10 m with sea grass beds has been found, with speed and displacement from capture locations being similar at night as during the daytime (Senko *et al.* 2010a).

Habitat. Green turtles appear to prefer waters that usually remain around 20º C in the coldest month, but may occur considerably north of these regions during warm-water events, such as El Niño. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18º C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998a). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal and Bolten 2000). Strong site fidelity appears to be a characteristic of juveniles green sea turtles along the Pacific Baja coast (Senko *et al.* 2010b).
Green sea turtles in the Gulf of Mexico tend to remain along the coast (lagoons, channels, inlets, and bays), with nesting primarily occurring in Florida and Mexico and infrequent nesting in all other areas (Landry and Costa 1999; Meylan *et al.* 1995; NMFS and USFWS 1991; USAF 1996). Foraging areas seem to be based upon seagrass and macroalgae abundance, such as in the Laguna Madre of Texas. However, green sea turtles may also occur in offshore regions, particularly during migration and development.

Feeding. While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley *et al.* 1998; Hatase *et al.* 2006; Seminoff *et al.* 2002a). A shift to a more herbivorous diet occurs when individuals move into neritic habitats, as vegetable mater replaces an omnivorous diet at around 59 cm in carapace length off Mauritania (Cardona *et al.* 2009). This transition may occur rapidly starting at 30 cm carapace length, but animal prey continue to constitute an important nutritional component until individuals reach about 62 cm (Cardona *et al.* 2010). Foraging within seagrass ecosystems by green sea turtles can be significant enough to alter habitat and ecological parameters, such as species composition (Lal *et al.* 2010).

Diving. Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, we presume that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (Hazel *et al.* 2009; NMFS and USFWS 1998a). Recent data from Australia indicate green sea turtles rarely dive deep,

staying in upper 8 m of the water column (Hazel *et al.* 2009). Here, daytime dives were shorter and shallower than were nighttime dives. Also, time spent resting and dive duration increased significantly with decreases in seasonal water temperatures. The maximum recorded dive depth for an adult green turtle was just over 106 m (Berkson 1967), while sub-adults routinely dive to 20 m for 9-23 min, with a maximum recorded dive of over 1 h (Brill *et al.* 1995; I-Jiunn 2009). Green sea turtles along Taiwan may rest during long, shallow dives (I-Jiunn 2009). Dives by females may be shorter in the period leading up to nesting (I-Jiunn 2009).

Status and trends. Federal listing of the green sea turtle occurred on July 28, 1978, with all populations listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are endangered (43 FR 32800). The International Union for Conservation of Nature (IUCN) has classified the green turtle as "endangered."

No trend data are available for almost half of the important nesting sites, where numbers are based on recent trends and do not span a full green sea turtle generation, and impacts occurring over four decades ago that caused a change in juvenile recruitment rates may have yet to be manifested as a change in nesting abundance. The numbers also only reflect one segment of the population (nesting females), who are the only segment of the population for which reasonably good data are available and are cautiously used as one measure of the possible trend of populations.

Nesting sites worldwide include both large and small rookeries believed to be representative of the overall trends for their respective regions. Based on the mean annual reproductive effort, 108,761-150,521 females nest each year among the 46 sites. Overall, of the 26 sites for which data enable an assessment of current trends, 12 nesting populations are increasing, 10 are stable, and four are decreasing. Long-term continuous datasets of 20 years are available for 11 sites, all of which are either increasing or stable. Despite the apparent global increase in numbers, the positive overall trend should be viewed cautiously because trend data are available for just over half of all sites examined and very few data sets span a full green sea turtle generation (Seminoff 2004).

Atlantic Ocean. Primary sites for green sea turtle nesting in the Atlantic/Caribbean include: (1) Yucatán Peninsula, Mexico; (2) Tortuguero, Costa Rica; (3) Aves Island, Venezuela; (4) Galibi Reserve, Suriname; (5) Isla Trindade, Brazil; (6) Ascension Island, United Kingdom; (7) Bioko Island, Equatorial Guinea; and (8) Bijagos Achipelago, Guinea-Bissau (NMFS and USFWS 2007a). Nesting at all of these sites was considered to be stable or increasing with the exception of Bioko Island and the Bijagos Archipelago where the lack of sufficient data precluded a meaningful trend assessment for either site (NMFS and USFWS 2007a). Seminoff (2004) likewise reviewed green sea turtle nesting data for eight sites in the western, eastern, and central Atlantic, including all of the above with the exception that nesting in Florida was reviewed in place of Isla Trindade, Brazil. Seminoff (2004) concluded that all sites in the central and western Atlantic showed increased nesting, with the exception of nesting at Aves Island, Venezuela, while both sites in the eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic. However, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007a).

The vast majority of green sea turtle nesting within the southeastern United States occurs in Florida (Meylan *et al.* 1995, Johnson and Ehrhart 1994). Green sea turtle nesting in Florida has been increasing since 1989 (Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute Index Nesting Beach Survey Database). Since establishment of the index beaches in 1989, the pattern of green turtle nesting shows biennial peaks in abundance with a generally positive trend during the ten years of regular monitoring. This is perhaps due to increased protective legislation throughout the Caribbean (Meylan *et al.* 1995). A total statewide average (all beaches, including index beaches) of 5,039 green turtle nests were laid annually in Florida between 2001 and 2006, with a low of 581 in 2001 and a high of 9,644 in 2005 (NMFS and USFWS 2007a). Data from the index nesting beaches program in Florida substantiate the dramatic increase in nesting. In 2007, there were 9,455 green turtle nests found just on index nesting beaches, the highest since index beach monitoring began in 1989. The number fell back to 6,385 in 2008, further dropping under 3,000 in 2009, but that consecutive drop was a temporary deviation from the normal biennial nesting cycle for green turtles, as 2010 saw an increase back to 8,426 nests on the index nesting beaches (FWC Index Nesting Beach Survey Database). Occasional nesting has been documented along the Gulf coast of Florida, at southwest Florida beaches, as well as the beaches on the Florida Panhandle (Meylan et al. 1995). More recently, green turtle nesting occurred on Bald Head Island, North Carolina; just east of the mouth of the Cape Fear River; on Onslow Island; and on Cape Hatteras National Seashore. In 2010, a total of 18 nests were found in North Carolina, 6 nests in South Carolina, and 6 nests in Georgia (nesting databases maintained on www.seaturtle.org). Increased nesting has also been observed along the Atlantic coast of Florida, on beaches where only loggerhead nesting was observed in the past (Pritchard 1997). Recent modeling by Chaloupka *et al.* (2007) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9 percent, and the Tortuguero, Costa Rica, population growing at 4.9 percent annually.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas of the southeastern United States, where they come to forage. However, information on incidental captures of immature green sea turtles at the St. Lucie Power Plant in St. Lucie County, Florida, shows that the annual number of immature green sea turtles captured by their offshore cooling water intake structures has increased significantly over the years. Green sea turtle annual captures averaged 19 for 1977-1986, 178 for 1987-1996, and 262 for 1997-2001 (FPL 2002). In the five years from 2002-2006, green sea turtle captures averaged 333 per year, with a high of 427 and a low of 267 (FPL and Quantum Resources 2007). More recent unpublished data shows 101 captures in 2007, 299 in 2008, 38 in 2009 (power output was cut—and cooling water intake concomitantly reduced—for part of that year) and 413 in 2010. Ehrhart *et al.* (2007) has also documented a significant increase in in-water abundance of green turtles in the Indian River Lagoon area. It is likely that immature green sea turtles foraging in the southeastern United States come from multiple genetic stocks; therefore, the status of immature green sea turtles in the southeastern United States might also be assessed from trends at all of the main regional nesting beaches, principally Florida, Yucatán, and Tortuguero.

Natural threats. Herons, gulls, dogfish, and sharks prey upon hatchlings. Adults face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level,

which can be lethal. For unknown reasons, the frequency of a disease called fibropapillomatosis is much higher in green sea turtles than in other species and threatens a large number of existing subpopulations. Extremely high incidence has been reported in Hawaii, where affliction rates peaked at 47-69% in some foraging areas (Murakawa *et al.* 2000). A to-date unidentified virus may aid in the development of fibropapillomatosis (Work *et al.* 2009). Predators (primarily of eggs and hatchlings) also include dogs, pigs, rats, crabs, sea birds, reef fishes, and groupers (Bell *et al.* 1994; Witzell 1981). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint *et al.* 2009).

Anthropogenic threats. Major anthropogenic impacts to the nesting and marine environment affect green sea turtle survival and recovery. At nesting beaches, green sea turtles rely on intact dune structures, native vegetation, and normal beach temperatures for nesting (Ackerman 1997). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard *et al.* 1998; Lutcavage *et al.* 1997). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to nesting females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington *et al.* 2003; Witherington *et al.* 2007). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, particularly areas rich in seagrass and marine algae. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour *et al.* 1999; Lee Long *et al.* 2000; Waycott *et al.* 2005). Ingestion of plastic and other marine debris is another source of morbidity and mortality (Stamper *et al.* 2009). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n=34), although mortality appears to have results in three cases (Tourinho *et al.* 2009). Low-level bycatch has also been documented in longline fisheries (Petersen *et al.* 2009). Further, the introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996). Very few green sea turtles are bycaught in U.S. fisheries (Finkbeiner *et al.* 2011).

Green sea turtles have been found to contain the organochlorines chlordane, lindane, endrin, endosulfan, dieldrin, DDT and PCB (Gardner *et al.* 2003; Miao *et al.* 2001). Levels of PCBs found in eggs are considered far higher than what is fit for human consumption (van de Merwe *et al.* 2009). The heavy metals copper, lead, manganese, cadmium, and nickel have also been found in various tissues and life stages (Barbieri 2009). Arsenic also occurs in very high levels in green sea turtle eggs (van de Merwe *et al.* 2009). These contaminants have the potential to cause deficiencies in endocrine, developmental, and reproductive health, and depress immune function in loggerhead sea turtles (Keller *et al.* 2006; Storelli *et al.* 2007). Exposure to sewage effluent may also result in green sea turtle eggs harboring antibiotic-resistant strains of bacteria (Al-Bahry *et al.* 2009). DDE has not been found to influence sex determination at levels below cytotoxicity (Keller and McClellan-Green 2004; Podreka *et al.* 1998). To date, no tie has been found between pesticide concentration and susceptibility to fibropapillomatosis, although

degraded habitat and pollution have been tied to the incidence of the disease (Aguirre *et al.* 1994; Foley *et al.* 2005). Flame retardants have been measured from healthy individuals (Hermanussen *et al.* 2008). It has been theorized that exposure to tumor-promoting compounds produced by the cyanobacteria *Lyngbya majuscule* could promote the development of fibropapillomatosis (Arthur *et al.* 2008). It has also been theorized that dinoflagellates of the genus *Prorocentrum* that produce the tumorogenic compound okadoic acid may influence the development of fibropapillomatosis (Landsberg *et al.* 1999).

Critical habitat. On September 2, 1998, critical habitat for green sea turtles was designated in coastal waters surrounding Culebra Island, Puerto Rico (63 FR 46693). Aspects of these areas that are important for green sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for green sea turtle prey.

Loggerhead sea turtle, Western Atlantic DPS

Distribution. Western Atlantic nesting locations include The Bahamas, Brazil, and numerous locations from the Yucatán Peninsula to North Carolina (Addison 1997; Addison and Morford 1996; Marcovaldi and Chaloupka 2007). This group comprises five nesting subpopulations: Northern, Southern, Dry Tortugas, Florida Panhandle, and Yucatán. Additional nesting occurs on Cay Sal Bank (Bahamas), Cuba, the Bahamian Archipelago, Quintana Roo (Yucatan Peninsula), Colombia, Brazil, Caribbean Central America, Venezuela, and the eastern Caribbean Islands. Genetic studies indicate that, although females routinely return to natal beaches, males may breed with females from multiple populations and facilitate gene flow Bowen *et al.* (2005). The northwestern Atlantic DPS is considered to be bounded by the equator and 60º N latitude and extend east to 40º W in the Atlantic basin; this is based upon oceanographic features satellite telemetry, sightings, and bycatch data (Conant *et al.* 2009).

Reproduction and growth. Loggerhead nesting is confined to lower latitudes temperate and subtropic zones but absent from tropical areas (NMFS and USFWS 1991b; NRC 1990; Witherington *et al.* 2006b). The life cycle of loggerhead sea turtles can be divided into seven stages: eggs and hatchlings, small juveniles, large juveniles, sub-adults, novice breeders, first year emigrants, and mature breeders (Crouse *et al.* 1987). Hatchling loggerheads migrate to the ocean (to which they are drawn by near ultraviolet light Kawamura *et al.* 2009), where they are generally believed to lead a pelagic existence for as long as 7-12 years (NMFS 2005). Loggerheads in the Mediterranean, similar to those in the Atlantic, grow at roughly 11.8 cm/yr for the first six months and slow to roughly 3.6 cm/yr at age 2.5-3.5. As adults, individuals may experience a secondary growth pulse associated with shifting into neritic habitats, although growth is generally monotypic (declines with age Casale *et al.* 2009a; Casale *et al.* 2009b). Individually-based variables likely have a high impact on individual-to-individual growth rates (Casale *et al.* 2009b). At 15-38 years, loggerhead sea turtles become sexually mature, although the age at which they reach maturity varies widely among populations Frazer *et al.* 1994(Casale *et al.* 2009b; Frazer and Ehrhart 1985; NMFS 2001; Witherington *et al.* 2006). However, based on new data from tag returns, strandings, and nesting surveys, NMFS SEFSC (2001) estimated ages of maturity ranging from 20-38 years and benthic immature stage lasting from 14-32 years.

Loggerhead mating likely occurs along migration routes to nesting beaches, as well as in offshore from nesting beaches several weeks prior to the onset of nesting (Dodd 1988a; NMFS and USFWS 1998d). Females usually breed every 2-3 years, but can vary from 1-7 years (Dodd 1988a; Richardson *et al.* 1978). Females lay an average of 4.1 nests per season (Murphy and Hopkins 1984) , although recent satellite telemetry from nesting females along southwest Florida support 5.4 nests per female per season, with increasing numbers of eggs per nest during the course of the season (Tucker 2009). The authors suggest that this finding warrants revision of the number of females nesting in the region. The western Atlantic breeding season is March-August. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).

Migration and movement. Loggerhead hatchlings migrate offshore and become associated with *Sargassum* spp. habitats, driftlines, and other convergence zones (Carr 1986). After 14-32 years of age, they shift to a benthic habitat, where immature individuals forage in the open ocean and coastal areas along continental shelves, bays, lagoons, and estuaries (Bowen *et al.* 2004; NMFS 2001). Adult loggerheads make lengthy migrations from nesting beaches to foraging grounds (TEWG 1998b). In the Gulf of Mexico, larger females tend to disperse more broadly after nesting than smaller individuals, which tend to stay closer the nesting location (Girard *et al.* 2009). In the North Atlantic, loggerheads travel north during spring and summer as water temperatures warm and return south in fall and winter, but occur offshore year-round assuming adequate temperature. For immature individuals, this movement occurs in two patterns: a north-south movement over the continental shelf with migration south of Cape Hatteras in winter and movement north along Virginia for summer foraging, and a not-so-seasonal oceanic dispersal into the Gulf Stream as far north as the 10-15˚ C isotherm (Mansfield *et al.* 2009). Wallace *et al.* (2009) suggested differences in growth rate based upon these foraging strategies. There is conflicting evidence that immature loggerheads roam the oceans in currents and eddies and mix from different natal origins or distribute on a latitudinal basis that corresponds with their natal beaches (Monzon-Arguello *et al.* 2009; Wallace *et al.* 2009). McCarthy *et al.* (2010) found that movement patterns of loggerhead sea turtles were more convoluted when sea surface temperatures were higher, ocean depths shallower, ocean currents stronger, and chlorophyll a levels lower.

Sighting and stranding records support loggerhead sea turtles to be common, year-round residents of the Gulf of Mexico, although their abundance is much greater in the northeastern region versus the northwestern (Davis *et al.* 2000; Fritts *et al.* 1983; Landry and Costa 1999). Loggerheads may occur in both offshore habitats (particularly around oil platforms and reefs, where prey and shelter are available; (Davis *et al.* 2000; Fritts *et al.* 1983; Gitschlag and Herczeg 1994; Lohoefener *et al.* 1990; Rosman *et al.* 1987), as well as shallow bays and sounds (which may be important developmental habitat for late juveniles in the eastern Gulf of Mexico; (Davis *et al.* 2000; Lohoefener *et al.* 1990; USAF 1996). Offshore abundance in continental slope waters increases during the winter in the eastern Gulf of Mexico, as cooler inshore waters force individuals into warmer offshore areas (Davis *et al.* 2000).

Feeding. Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker *et al.* 2005). Hatchling loggerheads feed on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991b). Pelagic and benthic juveniles forage

on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988a; Wallace *et al.* 2009). Loggerheads in the deep, offshore waters of the western North Pacific feed on jellyfish, salps, and other gelatinous animals (Dodd Jr. 1988; Hatase *et al.* 2002). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998d). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich *et al.* 2010; Vander Zanden *et al.* 2010).

Diving. Loggerhead diving behavior varies based upon habitat, with longer surface stays in deeper habitats than in coastal ones. Off Japan, dives were shallower than 30 m (Sakamoto *et al.* 1993). Routine dives can last 4–172 min (Byles 1988; Renaud and Carpenter 1994; Sakamoto *et al.* 1990). The maximum-recorded dive depth for a post-nesting female was over 230 m, although most dives are far shallower (9-21 m(Sakamoto *et al.* 1990). Loggerheads tagged in the Pacific over the course of 5 months showed that about 70% of dives are very shallow (<5 m) and 40% of their time was spent within 1 m of the surface (Polovina *et al.* 2003; Spotila 2004b). During these dives, there were also several strong surface temperature fronts that individuals were associated with, one of 20° C at 28° N latitude and another of 17° C at 32° N latitude.

Status and trends. Loggerhead sea turtles were listed as nine distinct population segments on September 22, 2011 (76 FR 58868). 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 (Bjorndal *et al.* 2005). An important caveat for population trends analysis based on nesting beach data is that this may reflect trends in adult nesting females, but it may not reflect overall population growth rates well. Adult nesting females often account for less than 1% of total population numbers. The global abundance of nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004a).

Atlantic Ocean. The greatest concentration of loggerheads occurs in the Atlantic Ocean and the adjacent Caribbean Sea, primarily on the Atlantic coast of Florida, with other major nesting areas located on the Yucatán Peninsula of Mexico, Columbia, Cuba, South Africa (EuroTurtle 2006 as cited in LGL Ltd. 2007; Márquez 1990).

Loggerhead females lay 53,000-92,000 nests per year in the southeastern U.S. and the Gulf of Mexico, and the total number of nesting females is 32,000-56,000. All of these are currently in decline or data are insufficient to access trends (NMFS 2001; TEWG 1998a). Loggerheads from western North Atlantic nesting aggregations may or may not feed in the same regions from which they hatch. Loggerhead sea turtles from the northern nesting aggregation, which represents about 9% of the loggerhead nests in the western North Atlantic, comprise 25-59% of individuals foraging from Georgia up to the northeast U.S. (Bass *et al.* 1998; Norrgard 1995; Rankin-Baransky 1997; Sears 1994; Sears *et al.* 1995). Loggerheads associated with the South Florida nesting aggregation occur in higher frequencies in the Gulf of Mexico (where they represent ~10% of the loggerhead captures) and the Mediterranean Sea (where they represent ~45% of loggerhead sea turtles captured). About 4,000 nests per year are laid along the

Brazilian coast (Ehrhart *et al.* 2003).

The northern recovery unit along Georgia, South Carolina, and North Carolina has a forty-year time-series trend showing an overall decline in nesting, but the shorter comprehensive survey data (20 years) indicate a stable population (SCDNR 2008; GDNR, NCWRC, and SCDNR nesting data located at www.seaturtle.org). NMFS scientists have estimated that the Northern subpopulation produces 65 percent males (NMFS SEFSC 2001).

The peninsular Florida recovery unit is the largest loggerhead nesting assemblage in the Northwest Atlantic. A near-complete nest census (all beaches including index nesting beaches) undertaken from 1989 to 2007 showed a mean of 64,513 loggerhead nests per year, representing approximately 15,735 nesting females per year (from NMFS and USFWS 2008). The statewide estimated total for 2010 was 73,702 (FWRI nesting database). An analysis of index nesting beach data shows a 26 percent decline in nesting by the PFRU between 1989 and 2008, and a mean annual rate of decline of 1.6 percent despite a large increase in nesting for 2008, to 38,643 nests (Witherington *et al.* 2009, NMFS and USFWS 2008, FWRI nesting database). In 2009, nesting levels, while still higher than the lows of 2004, 2006, and 2007, dropped below 2008 levels to approximately 32,717 nests, but in 2010 a large increase was seen, with 47,880 nests on the index nesting beaches (FWRI nesting database). The 2010 index nesting number is the largest since 2000. With the addition of data through 2010, the nesting trend for the NWA DPS of loggerheads is only slightly negative and not statistically different from zero (no trend) (NMFS and USFWS 2010). Preliminary, unofficial reports indicate that 2011 nesting may be a high nesting year on par with 2010.

Because of its size, the south Florida subpopulation of loggerheads may be critical to the survival of the species in the Atlantic, and in the past it was considered second in size only to the Oman nesting aggregation (NMFS 2006e; NMFS and USFWS 1991b). The South Florida population increased at ~5.3% per year from 1978-1990, and was initially increasing at 3.9-4.2% after 1990. An analysis of nesting data from 1989-2005, a period of more consistent and accurate surveys than in previous years, showed a detectable trend and, more recently (1998-2005), has shown evidence of a declining trend of approximately 22.3% (FFWCC 2007a; FFWCC 2007b; Witherington *et al.* 2009). This is likely due to a decline in the number of nesting females within the population (Witherington *et al.* 2009). Nesting data from the Archie Carr Refuge (one of the most important nesting locations in southeast Florida) over the last 6 years shows nests declined from approximately 17,629 in 1998 to 7,599 in 2004, also suggesting a decrease in population size[1]. Loggerhead nesting is thought to consist of just 60 nesting females in the Caribbean and Gulf of Mexico (NMFS 2006f). Based upon the small sizes of almost all nesting aggregations in the Atlantic, the large numbers of individuals killed in fisheries, and the decline of the only large nesting aggregation, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic are only slightly lower than those of populations in the Pacific. Zurita *et al.* (2003) found a statistically significant increase in the number of nests on seven of the beaches on Quintana Roo, Mexico, from 1987-2001, where survey effort was consistent

1 While this is a long period of decline relative to the past observed nesting pattern at this location, aberrant ocean surface temperatures complicate the analysis and interpretation of these data. Although caution is warranted in interpreting the decreasing nesting trend given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, the recent nesting decline at this nesting beach is reason for concern.

during the period. However, nesting has declined since 2001, and the previously reported increasing trend appears to not have been sustained (NMFS and USFWS 2008).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can pose lethal effects. In January 2010, an unusually large cold-stunning event occurred throughout the southeast United States, with well over 3,000 sea turtles (mostly greens but also hundreds of loggerheads) found cold-stunned. Most were able to be saved, but a few hundred were found dead or died after being discovered in a cold-stunned state. Eggs are commonly eaten by raccoons and ghost crabs along the eastern U.S. (Barton and Roth 2008). In the water, hatchlings are hunted by herons, gulls, dogfish, and sharks. Heavy loads of barnacles are associated with unhealthy or dead stranded loggerheads (Deem *et al.* 2009).

Anthropogenic threats. Anthropogenic threats impacting loggerhead nesting habitat are numerous: coastal development and construction, placement of erosion control structures, beachfront lighting, vehicular and pedestrian traffic, sand extraction, beach erosion, beach nourishment, beach pollution, removal of native vegetation, and planting of non-native vegetation (Baldwin 1992; Margaritoulis *et al.* 2003; Mazaris *et al.* 2009b; USFWS 1998). Surprisingly, beach nourishment also hampers nesting success, but only in the first year post-nourishment before hatching success increases (Brock *et al.* 2009). Loggerhead sea turtles face numerous threats in the marine environment as well, including oil and gas exploration, marine pollution, trawl, purse seine, hook and line, gill net, pound net, longline, and trap fisheries, underwater explosions, dredging, offshore artificial lighting, power plant entrapment, entanglement in debris, ingestion of marine debris, marina and dock construction and operation, boat collisions, and poaching. At least in the Mediterannean Sea, Anthorpogenic threats appear to disproportionally impact larger (more fecund) loggerheads (Bellido *et al.* 2010).
The major factors inhibiting their recovery include mortalities caused by fishery interactions and degradation of the beaches on which they nest. Shrimp trawl fisheries account for the highest number of captured and killed loggerhead sea turtles. Along the Atlantic coast of the U.S., the NMFS estimated that shrimp trawls capture almost 163,000 loggerhead sea turtles each year in the Gulf of Mexico, of which 3,948 die. However, more recent estimates from suggest interactions and mortality has decreased from pre-regulatory periods, with a conservative estimate of 26,500 loggerheads captured annually in U.S. Atlantic fisheries causing mortality to 1,400 individuals per year (Finkbeiner *et al.* 2011). Pacific bycatch is much less, with about 400 individuals bycaught annually in U.S. fisheries resulting in at least 20 mortalities (Finkbeiner *et al.* 2011). Each year, various fisheries capture about 2,000 loggerhead sea turtles in Pamlico Sound, of which almost 700 die. Along Baja California, it is estimated that 1,500-2,950 loggerheads are killed annually by local fishing fleets (Peckham *et al.* 2008). Offshore longline tuna and swordfish longline fisheries are also a serious concern for the survival and recovery of loggerhead sea turtles and appear to affect the largest individuals more than younger age classes (Aguilar *et al.* 1995; Bolten *et al.* 1994; Carruthers *et al.* 2009; Howell *et al.* 2008; Marshall *et al.* 2009; Petersen *et al.* 2009; Tomás *et al.* 2008). Deliberate hunting of loggerheads for their meat, shells, and eggs has declined from previous exploitation levels, but still exists and hampers recovery efforts (Lino *et al.* 2010).

Wallace *et al.* (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace *et al.* 2010); many of these are expected to be loggerhead sea turtles.
Marine debris ingestion can be a widespread issue for loggerhead sea turtles. More than one-third of loggerheads found stranded or bycaught had injected marine debris in a Mediterranean study, with possible mortality resulting in some cases (Lazar and Gračan 2010).

Climate change may also have significant implications on loggerhead populations worldwide. In addition to potential loss of nesting habitat due to sea level rise, loggerhead sea turtles are very sensitive to temperature as a determinant of sex while incubating. Ambient temperature increase by just 1º-2º C can potentially change hatchling sex ratios to all or nearly all female in tropical and subtropical areas (Hawkes *et al.* 2007). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin *et al.* 2009). Sea surface temperatures on loggerhead foraging grounds correlate to the timing of nesting, with higher temperatures leading to earlier nesting (Mazaris *et al.* 2009a; Schofield *et al.* 2009). Increasing ocean temperatures may also lead to reduced primary productivity and eventual food availability. This has been proposed as partial support for reduced nesting abundance for loggerhead sea turtles in Japan; a finding that could have broader implications for other populations in the future if individuals do not shift feeding habitat (Chaloupka *et al.* 2008). Warmer temperatures may also decrease the energy needs of a developing embryo (Reid *et al.* 2009).

Tissues taken from loggerheads sometimes contain very high levels of organochlorines chlorobiphenyl, chlordanes, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT, and PCB (Alava *et al.* 2006; Corsolini *et al.* 2000; Gardner *et al.* 2003; Keller *et al.* 2005; Keller *et al.* 2004a; Keller *et al.* 2004b; McKenzie *et al.* 1999; Monagas *et al.* 2008; Oros *et al.* 2009; Perugini *et al.* 2006; Rybitski *et al.* 1995; Storelli *et al.* 2007). It appears that levels of organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller *et al.* 2004c; Keller *et al.* 2006; Oros *et al.* 2009). These contaminants could cause deficiencies in endocrine, developmental, and reproductive health (Storelli *et al.* 2007). It is likely that the omnivorous nature of loggerheads makes them more prone to bioaccumulating toxins than other sea turtle species (Godley *et al.* 1999; McKenzie *et al.* 1999).

Heavy metals, including arsenic, barium, cadmium, chromium, iron, lead, nickel, selenium, silver, copper, zinc, and manganese, have also been found in a variety of tissues in levels that increase with turtle size (Anan *et al.* 2001; Fujihara *et al.* 2003; Garcia-Fernandez *et al.* 2009; Gardner *et al.* 2006; Godley *et al.* 1999; Saeki *et al.* 2000; Storelli *et al.* 2008). These metals likely originate from plants and seem to have high transfer coefficients (Anan *et al.* 2001; Celik *et al.* 2006; Talavera-Saenz *et al.* 2007).

Loggerhead sea turtles have higher mercury levels than any other sea turtle studied, but concentrations are an order of magnitude less than many toothed whales (Godley *et al.* 1999; Pugh and Becker 2001). Arsenic occurs at levels several fold more concentrated in loggerhead sea turtles than marine mammals or seabirds.

Also of concern is the spread of antimicrobial agents from human society into the marine environment. Loggerhead sea turtles may harbor antibiotic-resistant bacteria, which may have developed and thrived as a result of high use and discharge of antimicrobial agents into freshwater and marine ecosystems (Foti *et al.* 2009).

Critical habitat. The NMFS has not designated critical habitat for loggerhead sea turtles.

Kemp's ridley sea turtle

Distribution. The Kemp's ridley was formerly known only from the Gulf of Mexico and along the Atlantic coast of the U.S. (TEWG 2000). However, recent records support Kemp's ridley sea turtles distribution extending into the Mediterranean Sea on occasion (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico.

Movement and migration. Tracking of post-nesting females from Rancho Nuevo and Texas beaches indicates that turtles move along coastal migratory corridors either to the north or south from the nesting beach (Byles 1989b; Byles and Plotkin 1994; Renaud 1995b; Renaud *et al.* 1996; Shaver 1999; Shaver 2002). These migratory corridors appear to extend throughout the coastal areas of the Gulf of Mexico and most turtles appear to travel in waters less than roughly 164 feet in depth. Turtles that headed north and east traveled as far as southwest Florida, whereas those that headed south and east traveled as far as the Yucatan Peninsula, Mexico (Morreale *et al.* 2007).

Following migration, Kemp's ridley sea turtles settle into resident feeding areas for several months (Byles and Plotkin 1994; Morreale *et al.* 2007). Females may begin returning along relatively shallow migratory corridors toward the nesting beach in the winter in order to arrive at the nesting beach by early spring.

Reproduction. Mating is believed to occur about three to four weeks prior to the first nesting (Rostal 2007), or late March through early to mid April. It is presumed that most mating takes place near the nesting beach (Morreale *et al.* 2007; Rostal 2007). Females initially ovulate within a few days after successful mating and lay the first clutch approximately two to four weeks later; if a turtle nests more than once per season, subsequent ovulations occur within approximately 48 hours after each nesting (Rostal 2007).

Approximately 60% of Kemp's ridley nesting occurs along an approximate 25-mile stretch of beach near Rancho Nuevo, Tamaulipas, Mexico from April to July, with limited nesting to the north (100 nests along Texas in 2006) and south (several hundred nests near Tampico, Mexico in 2006 USFWS 2006). Nesting at this location may be particularly important because hatchlings can more easily migrate to foraging grounds (Putman *et al.* 2010). The Kemp's ridley sea turtle tends to nest in large aggregations or arribadas (Bernardo and Plotkin 2007). The period between Kemp's ridley arribadas averages approximately 25 days, but the precise timing of the arribadas is unpredictable (Bernardo and Plotkin 2007; Rostal *et al.* 1997). Like all sea turtles,

Kemp's ridley sea turtles nest multiple times in a single nesting season. The most recent analysis suggests approximately 3.075 nests per nesting season per female (Rostal 2007). The annual average number of eggs per nest (clutch size) is 94 to 100 and eggs typically take 45 to 58 days to hatch, depending on temperatures (Marquez-M. 1994; Rostal 2007; USFWS 2000; USFWS 2001; USFWS 2002; USFWS 2003; USFWS 2004; USFWS 2005a; USFWS 2006). The period between nesting seasons for each female is approximately 1.8 to 2.0 years (Marquez *et al.* 1989; Rostal 2007; TEWG 2000). The nesting beach at Rancho Nuevo may produce a "natural" hatchling sex ratio that is female-biased, which can potentially increase egg production as those turtles reach sexual maturity (Coyne and Landry Jr. 2007; Wibbels 2007).

Growth. Kemp's ridleys require approximately 1.5 to two years to grow from a hatchling to a size of approximately 7.9 inches long, at which size they are capable of making a transition to a benthic coastal immature stage, but can range from one to four years or more (Caillouet *et al.* 1995; Ogren 1989; Schmid 1998; Schmid and Witzell 1997; Snover *et al.* 2007; TEWG 2000; Zug *et al.* 1997). Based on the size of nesting females, it is assumed that turtles must attain a size of approximately 23.6 inches long prior to maturing (Marquez-M. 1994). Growth models based on mark-recapture data suggest that a time period of seven to nine years would be required for this growth from benthic immature to mature size (Schmid and Witzell 1997; Snover *et al.* 2007). Currently, age to sexual maturity is believed to range from approximately 10 to 17 years for Kemp's ridleys (Snover *et al.* 2007). However, estimates of 10 to 13 years predominate in previous studies (Caillouet *et al.* 1995; Schmid and Witzell 1997; TEWG 2000).

Habitat. Stranding data indicate that immature turtles in this benthic stage are found in coastal habitats of the entire Gulf of Mexico and U.S. Atlantic coast (Morreale *et al.* 2007; TEWG 2000). Developmental habitats for juveniles occur throughout the entire coastal Gulf of Mexico and U.S. Atlantic coast northward to New England (Morreale *et al.* 2007; Schmid 1998; Wibbels *et al.* 2005). Key foraging areas in the Gulf of Mexico include Sabine Pass, Texas; Caillou Bay and Calcasieu Pass, Louisiana; Big Gulley, Alabama; Cedar Keys, Florida; and Ten Thousand Islands, Florida (Carr and Caldwell 1956; Coyne *et al.* 1995; Ogren 1989; Schmid 1998; Schmid *et al.* 2002; Witzell *et al.* 2005). Foraging areas studied along the Atlantic coast include Pamlico Sound, Chesapeake Bay, Long Island Sound, Charleston Harbor, and Delaware Bay. Near-shore waters of 120 feet or less provide the primary marine habitat for adults, although it is not uncommon for adults to venture into deeper waters (Byles 1989a; Mysing and Vanselous 1989; Renaud *et al.* 1996; Shaver *et al.* 2005; Shaver and Wibbels 2007b). Benthic coastal waters of Louisiana and Texas seem to be preferred foraging areas for Kemp's ridley sea turtles (particularly passes and beachfronts), although individuals may travel along the entire coastal margin of the Gulf of Mexico (Landry and Costa 1999; Landry *et al.* 1996; Renaud 1995a). Sightings are less frequent during winter and spring, but this is likely due to lesser sighting effort during these times (Keinath *et al.* 1996; Shoop and Kenney 1992).

Feeding. Kemp's ridley diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks. A 2005 dietary study of immature Kemp's ridleys off southwest Florida documented predation on benthic tunicates, a previously undocumented food source for this species (Witzell and Schmid 2005).

Diving. Kemp's ridley sea turtles can dive from a few seconds in duration to well over two and a half hours, although most dives are from 16 to 34 minutes (Mendonca and Pritchard 1986; Renaud 1995b). Individuals spend the vast majority of their time underwater; over 12-hour periods, 89% to 96% of their time is spent below the surface (Byles 1989b; Gitschlag 1996).

Status and trends. The Kemp's ridley sea turtle was listed as endangered on December 2, 1970 (35 FR 18319). Internationally, the Kemp's ridley is considered the most endangered sea turtle (NRC 1990a; USFWS 1999).

During the mid 20th century, the Kemp's ridley was abundant in the Gulf of Mexico. Historic information indicates that tens of thousands of Kemp's ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). From 1978 through the 1980s, arribadas were 200 turtles or less, and by 1985, the total number of nests at Rancho Nuevo had dropped to approximately 740 for the entire nesting season, or a projection of roughly 234 turtles (TEWG 2000; USFWS and NMFS 1992). Beginning in the 1990s, an increasing number of beaches in Mexico were being monitored for nesting, and the total number of nests on all beaches in Tamaulipas and Veracruz in 2002 was over 6,000; the rate of increase from 1985 to 1999 was 11.3% annually (TEWG 2000; USFWS 2002). In 2006, approximately 7,866 nests were laid at Rancho Nuevo with the total number of nests for all the beaches in Mexico estimated at about 12,000 nests, which amounted to about 4,000 nesting females based upon three nests per female per season (Rostal 2007; Rostal *et al.* 1997; USFWS 2006). Considering remigration rates, the population included approximately 7,000 to 8,000 adult female turtles at that time (Marquez *et al.* 1989; Rostal 2007; TEWG 2000). Most recently, the 2007 nesting season included an arribada of over 4,000 turtles over a three-day period at Rancho Nuevo (P. Burchfield, pers. comm. in NMFS and USFWS 2007). The increased recruitment of new adults is illustrated in the proportion of first time nesters, which has increased from 6% in 1981 to 41% in 1994. Average population growth was estimated at 13% per year between 1991 and 1995 (TEWG 1998b). In 2008, there were 17,882 nests in Mexico (Gladys Porter Zoo 2008), and nesting in 2009 reached 21,144 (Gladys Porter Zoo 2010). In 2010, nesting declined significantly, to 13,302 (Gladys Porter Zoo 2010) but it is too early to determine if this is a one-time decline or if is indicative of a change in the trend. Population modelling used by the TEWG (2000) projected that Kemp's ridleys could reach the recovery plan's intermediate recovery goal of 10,000 nesters by the year 2015. Recent calculations of nesting females determined from nest counts show that the population trend is increasing towards that recovery goal, with an estimate of 4,047 nesters in 2006 and 5,500 in 2007 (NMFS 2007f, Gladys Porter Zoo 2007).

Nesting has also expanded geographically, with a headstart program reestablishing nesting on South Padre Island starting in 1978. Growth remained slow until 1988, when rates of return started to grow slowly (Shaver and Wibbels 2007a). Nesting rose from 6 nests in 1996 to 128 in 2007, 195 in 2008, and 197 in 2009. Texas nesting then experienced a decline similar to that seen in Mexico for 2010, with 140 nests (National Park Service data, http://www.nps.gov/pais/naturescience/strp.htm), but nesting rebounded in 2011 with a record 199 nests (National Park Service data, http://www.nps.gov/pais/naturescience/current-season.htm).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can pose lethal effects. Kemp's ridley sea turtles are particularly prone to this phenomenon along Cape Cod (Innis *et al.* 2009).

Anthropogenic threats. Population decline has been curtailed due to the virtual elimination of sea turtle and egg harvesting, as well as assistance in hatching and raising hatchlings (head-start). However, habitat destruction remains a concern in the form of bottom trawling and shoreline development. Trawling destroys habitat utilized by Kemp's ridley sea turtles for feeding and construction activities can produce hazardous runoff. Bycatch is also a source of mortality for Kemp's ridley sea turtles (McClellan *et al.* 2009). Finkbeiner *et al.* (2011) estimated that annual bycatch interactions total at least 98,300 individuals annually for U.S. Atlantic fisheries (resulting in 2,700 mortalities or more). The vast majority of fisheries interactions with sea turtles in the U.S. are either Kemp's ridley's or loggerhead sea turtles (Finkbeiner *et al.* 2011).

Toxin burdens in Kemp's ridley sea turtles include DDT, DDE, PCBs, PFOA, PFOS, chlordane, and other organochlorines (Keller *et al.* 2005; Keller *et al.* 2004a; Lake *et al.* 1994; Rybitski *et al.* 1995). These contaminants have the potential to cause deficiencies in endocrine, developmental and reproductive health, and are known to depress immune function in loggerhead sea turtles (Keller *et al.* 2006; Storelli *et al.* 2007b). Along with loggerheads, Kemp's ridley sea turtles have higher levels of PCB and DDT than leatherback and green sea turtles (Pugh and Becker 2001a). Organochlorines, including DDT, DDE, DDD, and PCBs have been identified as bioaccumulative agents and in greatest concentration in subcutaneous lipid tissue (Rybitski *et al.* 1995). Concentrations ranged from 7.46 mu g/kg to 607 mu g/kg, with a mean of 252 mu g/kg in lipid tissue. Five PCB congeners composed most of the contaminants: 153/132, 138/158, 180, 118, and 187 in order of concentration. PCBs have also been identified in the liver, ranging in concentration from 272 ng/g to 655 ng/g of wet weight, values that are several fold higher than in other sea turtle species (Lake *et al.* 1994). However, concentrations are reportedly 5% of that which causes reproductive failure in snapping turtles. DDE was identified to range from 137 ng/g to 386 ng/g wet weight. Trans-nonachlor was found at levels between 129 ng/g and 275 ng/g wet weight. Blood samples may be appropriate proxies for organochlorines in other body tissues (Keller *et al.* 2004a).

Perfluorinated compounds in the forms of PFOA and PFOS have been identified in the blood of Kemp's ridley turtles at concentrations of 39.4 ng/mL and 3.57 ng/mL, respectively (Keller *et al.* 2005). PFCAs have also been detected. It is likely that age and habitat are linked to PFC bioaccumulation.

Oil can also be hazardous to Kemp's ridley turtles, with fresh oil causing significant mortality and morphological changes in hatchlings, but aged oil having no detectable effects (Fritts and McGehee 1981). Blood levels of metals are lower in Kemp's ridley sea turtles than in other sea turtles species or similar to them, with copper (215 ng/g to 1,300 ng/g), lead (0 to 34.3 ng/g), mercury (0.5 ng/g to 67.3 ng/g), silver (0.042 ng/g to 2.74 ng/g), and zinc (3,280 ng/g to 18,900 ng/g) having been identified (Innis *et al.* 2008; Orvik 1997). It is likely that blood samples can be used as an indicator of metal concentration. Mercury has been identified in all turtle species

studied, but are generally an order of magnitude lower than toothed whales. The higher level of contaminants found in Kemp's ridley sea turtles are likely due to this species tendency to feed higher on the food chain than other sea turtles. Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation.

Critical habitat. NMFS has not designated critical habitat for Kemp's ridley sea turtle.

Leatherback sea turtle

Distribution. Leatherbacks range farther than any other sea turtle species, having evolved physiological and anatomical adaptations that allow them to exploit cold waters (Frair *et al.* 1972; Greer *et al.* 1973; USFWS 1995). High-latitude leatherback range includes in the Atlantic includes the North and Barents Seas, Newfoundland and Labrador , Argentina, and South Africa (Goff and Lien 1988; Hughes *et al.* 1998; Luschi *et al.* 2003; Luschi *et al.* 2006; Márquez 1990; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998; Gill 1997; Hodge and Wing 2000).

Leatherbacks also occur in Mediterranean and Indian Ocean waters (Casale *et al.* 2003; Hamann *et al.* 2006a). Associations exist with continental shelf and pelagic environments and sightings occur in offshore waters of 7-27˚ C (CETAP 1982). Juvenile leatherbacks usually stay in warmer, tropical waters >21˚ C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James *et al.* 2005).

Atlantic Ocean. Previous genetic analyses of leatherbacks using only mitochondrial DNA (mtDNA) resulted in an earlier determination that within the Atlantic basin there are at least three genetically different nesting populations: the St. Croix nesting population (U.S. Virgin Islands), the mainland nesting Caribbean population (Florida, Costa Rica, Suriname/French Guiana), and the Trinidad nesting population (Dutton *et al.* 1999). Further genetic analyses using microsatellite markers in nuclear DNA along with the mtDNA data and tagging data has resulted in Atlantic Ocean leatherbacks now being divided into seven groups or breeding populations: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean/Guianas, West Africa, South Africa, and Brazil (TEWG 2007).

Growth and reproduction. It has been thought that they reach sexual maturity somewhat faster than other sea turtles (except Kemp's ridley), with an estimated range of 3-6 years (Rhodin 1985) to 13-14 years (Zug and Parham 1996). However, some recent research using sophisticated methods of analyzing leatherback ossicles has cast doubt on the previously accepted age to maturity figures, with leatherbacks in the western North Atlantic possibly not reaching sexual maturity until as late as 29 years of age (Avens and Goshe 2007). Female leatherbacks nest frequently (up to 10 nests per year) during a nesting season and nest about every 2-3 years. During each nesting, they produce 100 eggs or more in each clutch and, thus, can produce 700 eggs or more per nesting season (Schultz 1975). However, a significant portion (up to approximately 30 percent) of the eggs can be infertile. Thus, the actual proportion of eggs that can result in hatchlings is less than this seasonal estimate. The eggs incubate for 55-75 days before hatching.

Habitat. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Grant and Ferrell 1993; Schroeder and Thompson 1987; Shoop and Kenney 1992a; Starbird *et al.* 1993). 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; Collard 1990; Davenport and Balazs 1991; Frazier 2001; HDLNR 2002). Aerial surveys off the western U.S. support continental slope waters as having greater leatherback occurrence than shelf waters (Bowlby *et al.* 1994; Carretta and Forney 1993; Green *et al.* 1992; Green *et al.* 1993). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).

Areas above 30º N in the Atlantic appear to be popular foraging locations (Fossette *et al.* 2009b). Northern foraging areas were proposed for waters between 35º and 50º N along North American, Nova Scotia, the Gulf of Saint-Laurent, in the western and northern Gulf Stream, the Northeast Atlantic, the Azores front and northeast of the Azores Islands, north of the Canary Islands. Southern foraging was proposed to occur between 5º and 15º N in the Mauritania upwelling, south of the Cape Verde islands, over the Guinea Dome area, and off Venezuela, Guyana and Suriname.

Migration and movement. Leatherback sea turtles migrate throughout open ocean convergence zones and upwelling areas, along continental margins, and in archipelagic waters (Eckert 1998; Eckert 1999; Morreale *et al.* 1994). In a single year, a leatherback may swim more than 9,600 km to nesting and foraging areas throughout ocean basins (Benson *et al.* 2007a; Benson *et al.* 2007b; Eckert 1998; Eckert 2006; Eckert *et al.* 2006; Ferraroli *et al.* 2004; Hays *et al.* 2004; Sale *et al.* 2006). Much of this travel may be due to movements within current and eddy features, moving individuals along (Sale and Luschi 2009). Return to nesting beaches may be accomplished by a form of geomagnetic navigation and use of local cues (Sale and Luschi 2009). Leatherback females will either remain in nearshore waters between nesting events, or range widely, presumably to feed on available prey (Byrne *et al.* 2009; Fossette *et al.* 2009a). Fossette *et al.* (2009b) identified three main migratory strategies in leatherbacks in the North Atlantic (almost all of studied individuals were female). One involved 12 individuals traveling to northern latitudes during summer/fall and returning to waters during winter and spring. Another strategy used by six individuals was similar to this, but instead of a southward movement in fall, individuals overwintered in northern latitudes (30-40º N, 25-30º W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10º in winter, where they remained or returned to the northwest Atlantic. A third strategy, which was followed by three females remaining in tropical waters for the first year subsequent to nesting and moving to northern latitudes during summer/fall and spending winter and spring in latitudes of 40-50º N.

Satellite tracking data reveal that leatherback females leaving Mexican and Central American nesting beaches migrate towards the equator and into Southern Hemisphere waters, some passing the Galápagos Islands, and disperse south of 10ºS (Dutton *et al.* 2006; Shillinger *et al.* 2010). However, observations of leatherbacks in the Galápagos Islands are rare (Zárate *et al.* 2010). Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave

exposure, possibly as a means to aid hatchling dispersal (Garcon *et al.* 2010). Individuals nesting in Malayasia undergo migrations to tropical feeding areas, taking 5-7 months to arrive there from nesting locations (Benson *et al.* 2011). Additional foraging occurs in temperate locations, including across the Pacific basin aloing the U.S. west coast; individuals take 10-12 months to migrate here (Benson *et al.* 2011). Individuals nesting during the boreal summer move to feeding areas in the North China Sea, while boreal winter nesters moved across the Equator to forage in the Southern Hemisphere (Benson *et al.* 2011).

Feeding. Leatherbacks may forage in high-invertebrate prey density areas formed by favorable features (Eckert 2006; Ferraroli *et al.* 2004). Although leatherbacks forage in coastal waters, they appear to remain primarily pelagic through all life stages (Heppell *et al.* 2003). The location and abundance of prey, including medusae, siphonophores, and salpae, in temperate and boreal latitudes likely has a strong influence on leatherback distribution in these areas (Plotkin 1995). Leatherback prey are frequently found in the deep-scattering layer in the Gulf of Alaska (Hodge and Wing 2000). North Pacific foraging grounds contain individuals from both eastern and western Pacific rookeries, although leatherbacks from the eastern Pacific generally forage in the Southern Hemisphere along Peru and Chile (Dutton 2005-2006; Dutton *et al.* 2000; Dutton *et al.* 1998). Mean primary productivity in all foraging areas of western Atlantic females is 150% greater than in eastern Pacific waters, likely resulting in twice the reproductive output of eastern Pacific females (Saba *et al.* 2007). Leatherbacks have been observed feeding on jellyfish in waters off Washington State and Oregon (Eisenberg and Frazier 1983; Stinson 1984b).

Diving. Leatherbacks are champion deep divers among sea turtles with a maximum-recorded dive of over 4,000 m (Eckert *et al.* 1989; López-Mendilaharsu *et al.* 2009). Dives are typically 50-84 m and 75-90% of time duration is above 80 m (Standora *et al.* 1984). Leatherbacks off South Africa were found to spend <1% of their dive time at depths greater than 200 m (Hays *et al.* 2009). Dive durations are impressive, topping 86 min, but routinely 1-14 min (Eckert *et al.* 1989; Eckert *et al.* 1996; Harvey *et al.* 2006; López-Mendilaharsu *et al.* 2009). Most of this time is spent traveling to and from maximum depths (Eckert *et al.* 1989). Dives are continual, with only short stays at the surface (Eckert *et al.* 1989; Eckert *et al.* 1986; Southwood *et al.* 1999). Off Playa Grande, Costa Rica, adult females spent 57–68% of their time underwater, diving to a mean depth of 19 m for 7.4 min (Southwood *et al.* 1999). Off St. Croix, adult females dove to a mean depth of 61.6 m for an average of 9.9 min, and spent an average of 4.9 min at the surface (Eckert *et al.* 1989). During shallow dives in the South China Sea, dives averaged 6.9–14.5 min, with a maximum of 42 min (Eckert *et al.* 1996). Off central California, leatherbacks dove to 20–30 m with a maximum of 92 m (Harvey *et al.* 2006). This corresponded to the vertical distribution if their prey (Harvey *et al.* 2006). Leatherback prey in the Gulf of Alaska are frequently concentrated in the deep-scattering layer (Hodge and Wing 2000). Mean dive and surface durations were 2.9 and 2.2 min, respectively (Harvey *et al.* 2006). In a study comparing diving patterns during foraging versus travelling, leatherbacks dove shallower (mean of 53.6 m) and moved more slowly (17.2 km/day) while in foraging areas while travelling to or from these areas (81.8 m and 51.0 km/day) (Fossette *et al.* 2009b).

Status and trends. Leatherback sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA, but declines in nesting have continued worldwide. Breeding females

were initially estimated at 29,000-40,000, but were later refined to ~115,000 (Pritchard 1971; Pritchard 1982). Spotila *et al.* (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004b). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001a; NMFS 2001b).

Nesting aggregations occur along Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida (Bräutigam and Eckert 2006; Márquez 1990; Spotila *et al.* 1996). Widely dispersed but fairly regular African nesting also occurs between Mauritania and Angola (Fretey *et al.* 2007). Many sizeable populations (perhaps up to 20,000 females annually) of leatherbacks are known to nest in West Africa (Fretey 2001a). The population of leatherbacks nesting on Gabon beaches has been suggested as being the world's largest, with 36,185-126,480 clutches being laid by 5,865-20,499 females annually from 2002-2007 (Witt *et al.* 2009). The total number of females utilizing Gabon nesting beaches is estimated to be 15,730- 41,373 (Witt *et al.* 2009). North Atlantic leatherbacks likely number 34,000-94,000 individuals, with females numbering 18,800 and the eastern Atlantic segment numbering 4,700 (TEWG 2007). Trends and numbers include only nesting females and are not a complete demographic or geographic cross-section. In 1996, the entire Western Atlantic population was characterized as stable at best (Spotila *et al.* 1996), with numbers of nesting females reported to be on the order of 18,800. A subsequent analysis by Spotila (pers. comm.) indicated that by 2000, the Western Atlantic nesting population had decreased to about 15,000 nesting females. Spotila *et al.* (1996) estimated that the leatherback population for the entire Atlantic basin, including all nesting beaches in the Americas, the Caribbean, and West Africa, totaled approximately 27,600 nesting females, with an estimated range of 20,082-35,133. This is consistent with the estimate of 34,000-95,000 total adults (20,000-56,000 adult females; 10,000-21,000 nesting females) determined by the TEWG (2007). The largest nesting aggregation in the western North Atlantic occurs in French Guiana and Suriname, likely belongs to a metapopulation whose limits remain unknown (Rivalan *et al.* 2006). Heppell *et al.* (2003) concluded that leatherbacks generally show less genetic structuring than green and hawksbill sea turtles. The French Guiana nesting aggregation has declined ~15% annually since 1987 (NMFS 2001b). However, from 1979-1986, the number of nests increased ~15% annually, possibly indicating the current decline may be linked with the erosion cycle of Guiana beaches (NMFS 2006e). Guiana nesting may have increased again in the early 2000s (NMFS 2006e). Suriname nesting numbers have recently increased from more than 10,000 nests annually since 1999 and a peak of 30,000 nests in 2001. Overall, Suriname and French Guiana nesting trends towards an increase (Girondot *et al.* 2007; Hilterman and Goverse 2003). Florida (March-July) and U.S. Caribbean nesting since the early 1980s has increased ~0.3% and 7.5% per year, respectively, but lags behind the French Guiana coast and elsewhere in magnitude (NMFS/SEFSC 2001). This positive growth was seen within major nesting areas for the stock, including Trinidad, Guyana, and the combined beaches of Suriname and French Guiana (TEWG 2007). Using both Bayesian modeling and regression analyses, the TEWG (2007) determined that the Southern Caribbean/Guianas stock had demonstrated a long-term, positive population growth rate (using nesting females as a proxy for population).

The Caribbean coast of Costa Rica and extending through Chiriquí Beach, Panama, represents the fourth largest known leatherback rookery in the world (Troëng *et al.* 2004). Examination of data from three index nesting beaches in the region (Tortuguero, Gandoca, and Pacuare in Costa Rica) using various Bayesian and regression analyses indicated that the nesting population likely

was not growing over the 1995-2005 time series of available data (TEWG 2007). Other modeling of the nesting data for Tortuguero indicates a possible 67.8 percent decline between 1995 and 2006 (Troëng *et al.* 2007).

In Puerto Rico, the primary nesting beaches are at Fajardo and on the island of Culebra. Nesting between 1978 and 2005 has ranged between 469-882 nests, and the population has been growing since 1978, with an overall annual growth rate of 1.1 percent (TEWG 2007). At the primary nesting beach on St. Croix, the Sandy Point National Wildlife Refuge, nesting has fluctuated from a few hundred nests to a high of 1,008 in 2001, and the average annual growth rate has been approximately 1.1 percent from 1986-2004 (TEWG 2007).

The Florida nesting stock nests primarily along the east coast of Florida. This stock is of growing importance, with total nests between 800-900 per year in the 2000s following nesting totals fewer than 100 nests per year in the 1980s (Florida Fish and Wildlife Conservation Commission, unpublished data). Using data from the index nesting beach surveys, the TEWG (2007) estimated a significant annual nesting growth rate of 1.17 percent between 1989 and 2005. In 2007, a record 517 leatherback nests were observed on the index beaches in Florida, with 265 in 2008, and then an increase to a new record of 615 nests in 2009, and a slight decline in 2010 back to 552 nests (FWC Index Nesting Beach database). This up-and-down pattern is thought to be a result of the cyclical nature of leatherback nesting, similar to the biennial cycle of green turtle nesting, but overall the trend shows rapid growth on Florida's east coast beaches. The most recent population estimate for leatherback sea turtles from just the North Atlantic breeding groups is a range of 34,000-90,000 adult individuals (20,000-56,000 adult females) (TEWG 2007).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales (Pitman and Dutton 2004). Hatchlings are preyed upon by herons, gulls, dogfish, and sharks. Leatherback hatching success is particularly sensitive to nesting site selection, as nests that are overwashed have significantly lower hatching success and leatherbacks nest closer to the high-tide line than other sea turtle species (Caut *et al.* 2009).

Anthropogenic threats. Leatherback nesting and marine environments are facing increasing impacts through widespread development and tourism along nesting beaches (Hamann *et al.* 2006a; Hernandez *et al.* 2007; Maison 2006; Santidrián Tomillo *et al.* 2007). Structural impacts to beaches include building and piling construction, beach armoring and renourishment, and sand extraction (Bouchard *et al.* 1998; Lutcavage *et al.* 1997). In some areas, timber and marine debris accumulation as well as sand mining reduce available nesting habitat (Bourgeois *et al.* 2009; Chacón Chaverri 1999; Formia *et al.* 2003; Laurance *et al.* 2008). Lights on or adjacent to nesting beaches alter nesting adult behavior and is often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Bourgeois *et al.* 2009; Cowan *et al.* 2002; Deem *et al.* 2007; Witherington 1992; Witherington and Bjorndal 1991). Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky *et al.* 2009). Along the coast of Peru, intestinal contents of 19 of 140 (13 percent) leatherback carcasses were found to contain plastic bags and film (Fritts 1982). Although global warming may expand foraging habitats into higher latitude waters, increasing temperatures may increase feminization of nests (Hawkes *et al.* 2007b; James *et al.* 2006;

McMahon and Hays 2006; Mrosovsky *et al.* 1984). Rising sea levels may also inundate nests on some beaches. Egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of females along nesting beaches is of concern worldwide.

Bycatch, particularly by longline fisheries, is a major source of mortality for leatherback sea turtles (Crognale *et al.* 2008; Fossette *et al.* 2009a; Gless *et al.* 2008; Petersen *et al.* 2009). Wallace *et al.* (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace *et al.* 2010); many of these turtles are expected to be leatherbacks. Donoso and Dutton (2010) found that 284 leatherbacks were bycaught between 2001 and 2005 as part of the Chilean longline fishery, with two individuals observed dead; leatherbacks were the most frequently bycaught sea turtle species. Between 8-17 leatherback turtles were estimated to have died annually between 1990 and 2000 in interactions with the California/Oregon drift gillnet fishery; 500 leatherback turtles are estimated to die annually in Chilean and Peruvian fisheries; 200 leatherback turtles are estimated to die in direct harvests in Indonesia; and, before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 1,000 leatherback turtles each year, killing about 111 of them each year. Finkbeiner *et al.* (2011) estimated that annual bycatch interactions total 1,400 individuals annually for U.S. Atlantic fisheries (resulting in roughly fourty mortalities) and one hundred interactions in U.S. Pacific fisheries (resulting in about ten mortalities). Mortality of leatherbacks in the U.S. shrimp fishery is now estimated at 54 turtles per year. Data collected by the NEFSC Fisheries Observer Program from 1994 through 1998 (excluding 1997) indicate that a total of 37 leatherbacks were incidentally captured (16 lethally) in drift gillnets set in offshore waters from Maine to Florida during this period. Observer coverage for this period ranged from 54 to 92%. Trinidad and Tobago's Institute for Marine Affairs estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000. As much as one-half or more of the gravid turtles in Trinidad and Tobago waters may be killed (Lee Lum 2003), though many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS 2001a).

We know little about the effects of contaminants on leatherback sea turtles. The metals arsenic, cadmium, copper, mercury, selenium, and zinc bioaccumulate, with cadmium in highest concentration in leatherbacks versus any other marine vertebrate (Caurant *et al.* 1999; Gordon *et al.* 1998). A diet of primarily jellyfish, which have high cadmium concentrations, is likely the cause (Caurant *et al.* 1999). Organochlorine pesticides have also been found (McKenzie *et al.* 1999). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight Davenport *et al.* 1990; Oros *et al.* 2009).

Critical habitat. On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, U.S.V.I. from the 183 m isobath to mean high tide level between 17° 42’12” N and 65°50’00” W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. However, studies do not currently support significant critical habitat deterioration.

On Janauary 26, 2012, the NMFS published a final rule to designate critical habitat for leatherback sea turtles in waters along Washington State (Cape Flattery to the Umpqua River; 63,455 km^2) and California (Point Arena to point Vincente; 119,400 km^2) (77 FR 4170). The primary constituent elements of these areas include 1) the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia, Phacellophora,* and *Cyanea*) of sufficient condition, distribution, diversity, and abundance to support individual as well as population growth, reproduction, and development and 2) migratory pathway conditions to allow for safe and timely passage and access to/from/within high use foraging areas.

Hawksbill sea turtle

Distribution. The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific oceans. Satellite tagged turtles have shown significant variation in movement and migration patterns. In the Caribbean, distance traveled between nesting and foraging locations ranges from a few kilometers to a few hundred kilometers (Byles and Swimmer 1994; Hillis-Starr *et al.* 2000; Horrocks *et al.* 2001; Lagueux *et al.* 2003; Miller *et al.* 1998; Prieto *et al.* 2001).

Population designation. Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. For example, genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the Western Atlantic, where the vast majority of nesting has been documented (McClellan *et al.* 2010; Monzon-Arguello *et al.* 2010).

Migration and movement. Upon first entering the sea, neonatal hawksbills in the Caribbean are believed to enter an oceanic phase that may involve long distance travel and eventual recruitment to nearshore foraging habitat (Boulon 1994). In the marine environment, the oceanic phase of juveniles (i.e., the "lost years") remains one of the most poorly understood aspects of hawksbill life history, both in terms of where turtles occur and how long they remain oceanic. Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave exposure, possibly as a means to aid hatchling dispersal(Garcon *et al.* 2010) .

Habitat. Hawksbill sea turtles are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Small juvenile hawksbills (5-21 cm straight carapace length) have been found in association with *Sargassum* spp. in both the Atlantic and Pacific oceans (Musick and Limpus 1997) and observations of newly hatched hawksbills attracted to floating weed have been made (Hornell 1927; Mellgren and Mann 1996; Mellgren *et al.* 1994). Post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997), and mud flats (R. von Brandis, unpublished data in NMFS and USFWS 2007b). Eastern Pacific adult females have recently been tracked in saltwater mangrove forests along El Salvador and Honduras, a habitat that this species was not previously known to occupy (Gaos *et al.* 2011). Individuals of multiple breeding locations can occupy the same foraging habitat (Bass 1999; Bowen *et al.* 1996;

Bowen *et al.* 2007; Diaz-Fernandez *et al.* 1999; Velez-Zuazo *et al.* 2008). As larger juveniles, some individuals may associate with the same feeding locality for more than a decade, while others apparently migrate from one site to another (Blumenthal *et al.* 2009a; Mortimer *et al.* 2003; Musick and Limpus 1997). Larger individuals may prefer deeper habitats than their smaller counterparts (Blumenthal *et al.* 2009a). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010). Hawksbill sea turtles appear to be rare visitors to the Gulf of Mexico, with Florida being the only Gulf state with regular sightings (Hildebrand 1983; NMFS and USFWS 1993; Rabalais and Rabalais 1980; Rester and Condrey 1996; Witzell 1983). Individuals stranded in Texas are generally young (hatchlings or yearlings) originating from Mexican nesting beaches (Amos 1989; Collard and Ogren 1990; Hildebrand 1983; Landry and Costa 1999).

Growth and reproduction. The best estimate of age at sexual maturity for hawksbill sea turtles is about 20-40 years (Chaloupka and Limpus 1997, Crouse 1999a). Reproductive females undertake periodic (usually non-annual) migrations to their natal beach to nest. Movements of reproductive males are less well known, but are presumed to involve migrations to their nesting beach or to courtship stations along the migratory corridor (Meylan 1999). Females nest an average of 3-5 times per season (Meylan and Donnelly 1999, Richardson *et al.* 1999). Clutch size is larger on average (up to 250 eggs) than that of other sea turtles (Hirth 1980). Reproductive females may exhibit a high degree of fidelity to their nest sites.
The life history of hawksbills consists of a pelagic stage that lasts from the time they leave the nesting beach as hatchlings until they are approximately 22-25 cm in straight carapace length (Meylan 1988, Meylan and Donnelly 1999), followed by residency in developmental habitats (foraging areas where juveniles reside and grow) in coastal waters.

Feeding. Dietary data from oceanic stage hawksbills are limited, but indicate a combination of plant and animal material (Bjorndal 1997).

Diving. Hawksbill diving ability varies with age and body size. As individuals increase with age, diving ability in terms of duration and depth increases (Blumenthal *et al.* 2009b). Studies of hawksbills in the Caribbean have found diurnal diving behavior, with dive duration nearly twice as long during nighttime (35-47 min) compared to daytime (19-26 min Blumenthal *et al.* 2009b; Van Dam and Diez 1997). Daytime dives averaged 5 m, while nighttime dives averaged 43 m (Blumenthal *et al.* 2009b)

Hawksbills have long dive durations, although dive depths are not particularly deep. Adult females along St. Croix reportedly have average dive times of 56 min, with a maximum time of 73.5 min (Starbird *et al.* 1999). Average day and night dive times were 34–65 and 42–74 min, respectively. Immature individuals have much shorter dives of 8.6–14 min to a mean depth of 4.7 m while foraging (Van Dam and Diez 1997).

Status and trends. Hawksbill sea turtles received protection on June 2, 1970 (35 FR 8495) under the Endangered Species Conservation Act and since 1973 have been listed as endangered under the ESA. Although no historical records of abundance are known, hawksbill sea turtles are considered to be severely depleted due to the fragmentation and low use of current nesting beaches (NMFS and USFWS 2007b). Worldwide, an estimated 21,212-28,138

hawksbills nest each year among 83 sites. Among the 58 sites for with historic trends, all show a decline during the past 20 to 100 years. Among 42 sites for which recent trend data are available, 10 (24%) are increasing, three (7%) are stable and 29 (69%) are decreasing. Encouragingly, nesting range along Mexico and Central America appears not to have contracted and estimates continue to increase as additional dedicated study is conducted in the eastern Pacific (Gaos *et al.* 2010).

Atlantic Ocean. Atlantic nesting sites include: Antigua (Jumby Bay), the Turks and Caicos, Barbados, the Bahamas, Puerto Rico (Mona Island), the U.S. Virgin Islands, the Dominican Republic, Sao Tome, Guadaloupe, Trinidad and Tobago, Jamaica, Martinique, Cuba (Doce Leguas Cays), Mexico (Yucatan Peninsula), Costa Rica (Tortuguero National Park), Guatemala, Venezuela, Bijagos Archipelago, Guinea-Bissau, and Brazil.

Population increase has been greater in the Insular Caribbean than along the Western Caribbean Mainland or the eastern Atlantic (including Sao Tomé and Equatorial Guinea). Nesting populations of Puerto Rico appeared to be in decline until the early 1990s, but have universally increased during the survey periods. Mona Island now hosts 199-332 nesting females annually, and the other sites combined host 51-85 nesting females annually (R.P. van Dam and C.E. Diez, unpublished data in NMFS and USFWS 2007b) C.E. Diez, Chelonia, Inc., in litt. to J. Mortimer 2006). The U.S. Virgin Islands have a long history of tortoiseshell trade (Schmidt 1916). At Buck Island Reef National Monument, protection has been in force since 1988, and during that time, hawksbill nesting has increased by 143% to 56 nesting females annually, with apparent spill over to beaches on adjacent St. Croix (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). However, St. John populations did not increase, perhaps due to the proximity of the legal turtle harvest in the British Virgin Islands (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). Populations have also been identified in Belize and Brazil as genetically unique (Hutchinson and Dutton 2007). An estimated 50-200 nests are laid per year in the Guinea-Bissau (Catry *et al.* 2009).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can be lethal. The only other significant natural threat to hawksbill sea turtles is from hybridization of hawksbills with other species of sea turtles. This is especially problematic at certain sites where hawksbill numbers are particularly low (Mortimer and Donnelly in review). Predators (primarily of eggs and hatchlings) include dogs, pigs, rats, crabs, sea birds, reef fishes, groupers, feral cats, and foxes (Bell *et al.* 1994; Ficetola 2008). In some areas, nesting beaches can be almost completely destroyed and all nests can sustain some level of depredation (Ficetola 2008).

Anthropogenic threats. Threats to hawksbill sea turtles are largely anthropogenic, both historically and currently. Impacts to nesting beaches include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard *et al.* 1998; Lutcavage *et al.* 1997). Because hawksbills prefer to nest under vegetation (Horrocks and Scott 1991; Mortimer 1982), they are particularly impacted by beachfront development and clearing of dune vegetation (Mortimer and Donnelly in review). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to

emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). One of the most detrimental human threats to hawksbill sea turtles is the intensive harvest of eggs from nesting beaches.

In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour *et al.* 1999; Lee Long *et al.* 2000; Waycott *et al.* 2005). Hawksbills are typically associated with coral reefs, which are among the world's most endangered marine ecosystems (Wilkinson 2000). Although primarily spongivorous, bycatch of hawksbill sea turtles in the swordfish fishery off South Africa occurs (Petersen *et al.* 2009). Finkbeiner *et al.* (2011) estimated that annual bycatch interactions total at least 20 individuals annually for U.S. Atlantic fisheries (resulting in less than ten mortalities) and no or very few interactions in U.S. Pacific fisheries.

Future impacts from climate change and global warming may result in significant changes in hatchling sex ratios. The fact that hawksbill turtles exhibit temperature-dependent sex determination (Wibbels 2003) suggests that there may be a skewing of future hawksbill cohorts toward strong female bias (since warmer temperatures produce more female embryos).

Critical habitat. On September 2, 1998, the NMFS established critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). Aspects of these areas that are important for hawksbill sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill sea turtle prey.

Shortnose sturgeon

Species Description, Distribution, and Population Structure. Shortnose sturgeon occur along the Atlantic Coast of North America, from the St. John River in Canada to the St. Johns River in Florida. The Shortnose sturgeon recovery plan (NMFS 1998) describes 19 shortnose sturgeon population segments that exist in the wild (Table 18). Two additional, geographically distinct populations occur behind dams in the Connecticut River (above the Holyoke Dam) and in Lake Marion on the Santee-Cooper River system in South Carolina (above the Wilson and Pinopolis Dams). Although these populations are geographically isolated, genetic analyses suggest that the shortnose sturgeon living downstream of the dams are not significantly different than those living upstream (Quattro *et al.* 2002, Wirgin *et al.* 2005).

At the northern end of the species' distribution, the highest rate of gene flow (which suggests migration) occurs between the Kennebec, Penobscot, and Androscoggin Rivers. At the southern end of the species' distribution, populations south of the Pee Dee River appear to exchange between 1 and 10 individuals per generation, with the highest rates of exchange between the Ogeechee and Altamaha Rivers (Wirgin *et al.* 2005). Wirgin *et al.* (2005) concluded that rivers separated by more than 400 kilometers were connected by very little migration while rivers separated by no more than 20 kilometers (such as the rivers flowing into coastal South Carolina) would experience high migration rates. Coincidentally, at the geographic center of the shortnose

sturgeon range, there is a 400 kilometer stretch of coast with no known populations occurring from the Delaware River, New Jersey to Cape Fear River, North Carolina (Kynard 1997). However, shortnose sturgeon are known to occur in the Chesapeake Bay, but they may be transients from the Delaware River via the Chesapeake and Delaware Canal (Skjeveland *et al.* 2000, Welsh *et al.* 2002) or remnants of a population in the Potomac River.

Rogers and Weber (1995), Kahnle *et al.* (1998), and Collins *et al.* (2000) concluded that shortnose sturgeon are extinct from the St. Johns River in Florida and the St. Marys River along the Florida and Georgia border. In 2002, a shortnose sturgeon was captured in the St. Johns River, FL (FFWCC 2007), suggesting either immigration or a small remnant population. Rogers and Weber (1995) also concluded that shortnose sturgeon have become extinct in Georgia's Satilla River.

Table 18. Known shortnose sturgeon population densities

Population/ Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Source
Saint John River	New Brunswick, Canada	1973/1977	18,000	30%	Dadswell 1979
Kennebecasis River	Canada	1998 – 2005	2,068	801 - 11,277	COSEWIC 2005
Penobscot River	ME	no data	-	-	
Kennbec River	ME	1977/1981	7,200	5,046 - 10,765	Squiers *et al.* 1982
		2003	9,500	6,942 - 13,358	Squiers 2003
Androscoggin River	ME		3,000		Squiers *et al.* 1993
Merrimack River	MA	1989 – 1990	33	18 - 89	NMFS 1998
Connecticut River	MA, CT	2003	-	1,500 - 1,800	Connecticut DEP 2003
		1998-2002	-	1,042 - 1,580	Savoy 2004
Above Holyoke Dam		1976 – 1977	515	317 - 898	Taubert 1980, NMFS 1998
		1977 – 1978	370	235 - 623	Taubert 1980, NMFS 1998

Population/ Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Source
		1976 – 1978	714	280 - 2,856	Taubert 1980, NMFS 1998
		1976 – 1978	297	267 - 618	Taubert 1980, NMFS 1998
Below Holyoke Dam		1988 – 1993	895	799 - 1,018	Savoy and Shake 1992, NMFS 1998
Hudson River	NY	1980	30,311		Dovel 1979, NMFS 1998
		1995	38,000	26,427 - 55,072	Bain *et al.* 1995, NMFS 1998
		1997	61,000	52,898 - 72,191	Bain *et al.* 2000
Delaware River	NJ, DE, PA	1981/1984	12,796	10,288 - 16,367	Hastings *et al.* 1987
		1999/2003	12,047	10,757 - 13,589	Brundage and O'Herron 2003
Chesapeake Bay	MD, VA	no data	-	-	
Potomac River	MD, VA	no data	-	-	
Neuse River	NC	2001-2002	extirpated		Oakley 2003
Cape Fear River	NC	1997	>100		Kynard 1997, NMFS 1998
Winyah Bay	NC, SC	no data	-	-	
Waccamaw - Pee Dee River	SC	no data	-	-	
Santee River	SC	no data	-	-	
Lake Marion (dam-locked)	SC	no data	-	-	

Population/ Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Source
Cooper River	SC	1996-1998	200	87-301	Cooke *et al.* 2005
ACE Basin	SC	no data	-	-	
Savannah River	SC, GA	1984-1992	1,676		Smith *et al.* 1995, NMFS 1998
		1984-1992		96-1075	NMFS 1998
Ogeechee River	GA	1990s	266		Bryce *et al.* 2002
		1993	266	236 - 300	Kirk *et al.* 2005
		1993	361	326 - 400	Rogers and Weber 1994
		1999/2000	195	-	Bryce *et al.* 2002
		2000	147	105 - 249	Kirk *et al.* 2005
		2004	174	97 - 874	Kirk *et al.* 2005
		2007	368	244-745	Peterson 2007 annual report
Altamaha River	GA	1988	2,862	1,069 - 4,226	NMFS 1998
		1990	798	645 - 1,045	NMFS 1998
		1993	468	315 - 903	NMFS 1998
Altamaha (continued)		2003-2005	6,320	4,387-9,249	DeVries 2006
Satilla River	GA		?	-	Kahnle *et al.* 1998
Saint Mary's River	FL		?	-	Kahnle *et al.* 1998, Rogers and Weber 1994

Population/ Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Source
Saint Johns River	FL	2002	1	-	FFWCC 2007

In addition to these wild populations there are several captive populations of shortnose sturgeon (Table 19). One captive population of shortnose sturgeon is maintained at the Conte Anadromous Fish Research Center in Massachusetts, which is operated by the USFWS. These sturgeon were taken from the Connecticut River population and are currently held by Dr. Boyd Kynard under Permit No. 1239. Captive populations of shortnose sturgeon captured from the Savannah River population are housed at three USFWS hatcheries: Bear's Bluff (South Carolina), Orangeburg (South Carolina), and Warm Springs (Georgia). The USFWS provides progeny of these captive shortnose sturgeon to other facilities for research, educational purposes, and public display.

Smaller captive populations that have been developed from USFWS facilities are maintained in several facilities for educational purposes. The South Carolina Aquarium in Charleston, South Carolina, maintains a population of eight juvenile shortnose sturgeon. The Springfield Science Museum in Springfield, Massachusetts, maintains a population of five juvenile shortnose sturgeon. Captive populations are also held in the North Carolina Zoo in Asheboro, North Carolina; National Aquarium in Baltimore, Maryland; and the Riverbanks Zoological Park in Columbia, South Carolina.

Table 19. Populations reared in captivity	
Conte Fish Research Center	MA
Bear's Bluff hatchery	SC
Orangeburg hatchery	SC
Warm Springs hatchery	GA

Life History Information. Shortnose sturgeon are anadromous fish that live primarily in slower moving rivers or nearshore estuaries near large river systems. They are benthic omnivores that feed on crustaceans, insect larvae, worms and mollusks (Moser and Ross 1995, NMFS 1998, Collins *et al.* 2008) but they have also been observed feeding off plant surfaces and on fish bait (Dadswell *et al.* 1984).

During the summer and winter, adult shortnose sturgeon occur in freshwater reaches of rivers or river reaches that are influenced by tides; as a result, they often occupy only a few short reaches of a river's entire length (Buckley and Kynard 1985). During the summer, at the southern end of their range, shortnose sturgeon congregate in cool, deep, areas of rivers where adult and juvenile sturgeon can take refuge from high temperatures (Flournoy *et al.* 1992, Rogers and Weber 1994, Rogers and Weber 1995, Weber 1996). Juvenile shortnose sturgeon generally move upstream for the spring and summer seasons and downstream for fall and winter; however, these movements usually occur above the salt- and freshwater interface of the rivers they inhabit (Dadswell *et al.* 1984, Hall *et al.* 1991). Because they rarely leave their natal rivers, Kieffer and Kynard (1993) considered shortnose sturgeon to be freshwater amphidromous (*i.e.* adults spawn

in freshwater but regularly enter saltwater habitats during their life). Adult shortnose sturgeon prefer deep downstream areas with soft substrate and vegetated bottoms, if present.

Shortnose sturgeon in the northern portion of the species' range live longer than individuals in the southern portion of the species' range (Gilbert 1989). The maximum age reported for female shortnose sturgeon are: 67 years in the St. John River (New Brunswick), 40 years for the Kennebec River, 37 years for the Hudson River, 34 years in the Connecticut River, 20 years in the Pee Dee River, and 10 years in the Altamaha River (Gilbert 1989 using data presented in Dadswell *et al.* 1984). Male shortnose sturgeon appear to have shorter life spans than females (Gilbert 1989).

Listing Status. Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001) pursuant to the Endangered Species Preservation Act of 1966. Shortnose sturgeon remained on the list as endangered with enactment of the ESA in 1973. Shortnose sturgeon were first listed on the International Union for Conservation of Nature and Natural Resources Red List in 1986 where they are still listed as Vulnerable and facing a high risk of extinction.

Status and Trends of Shortnose Sturgeon Populations. Despite the longevity of sturgeon, the viability of sturgeon populations are highly sensitive to increases in juvenile mortality that result in chronic reductions in the number of sub-adults that recruit into the adult breeding population (Anders *et al.* 2002, Gross *et al.* 2002, Secor *et al.* 2002). This relationship caused Secor *et al.* (2002) to conclude that sturgeon populations can be grouped into two demographic categories: populations that have reliable (albeit periodic) natural recruitment and those that do not. The shortnose sturgeon populations without reliable natural recruitment are at risk of becoming critically endangered, extinct in the wild, or extinct over portions or the entirety of their range.

Several authors have also demonstrated that sturgeon populations generally, and shortnose sturgeon populations in particular, are much more sensitive to adult mortality than other species of fish (Boreman 1997, Gross *et al.* 2002, Secor *et al.* 2002). These authors concluded that sturgeon populations cannot survive fishing related mortalities that exceed five percent of an adult spawning run and they are vulnerable to declines and local extinction if juveniles die from fishing related mortalities.

Based on the information available, most extant shortnose sturgeon populations in the northern portion of the species range, from the Delaware River north to the St. John River in Canada, appear to have sufficient juvenile survival to provide at least periodic recruitment into the adult age classes combined with relatively low adult mortality rates sufficient to maintain the viability of most of these populations. As a result, most of these populations appear to be relatively large and stable (Table 18).

Atlantic Sturgeon DPSs

Distribution. The Atlantic sturgeon's historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador to the Saint Johns River in Florida (Smith and Clugston 1997, ASSRT 2007). Atlantic sturgeon have been

documented as far south as Bermuda and Venezuela (Lee *et al.* 1980). Historically, Atlantic sturgeon were present in approximately 38 rivers in the United States from St. Croix, ME to the Saint Johns River, FL, of which 35 rivers have been confirmed to have had historic spawning populations. Atlantic sturgeon are currently present in 36 rivers, and spawning occurs in at least 20 of these. Other estuaries along the coast formed by rivers that do not support Atlantic sturgeon spawning populations may still be important rearing habitats.

Life history. While intensely studied since the 1970s, many important aspects of Atlantic sturgeon life history are still unknown. The general life history pattern of Atlantic sturgeon is that of a long lived, late maturing, iteroparous, anadromous species. The species' historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador to the Saint Johns River in Florida (reviewed in Murawski and Pacheco 1977, Smith and Clugston 1997). Atlantic sturgeon spawn in freshwater, but spend most of their sub-adult and adult life in the marine environment. While few specific spawning locations have been identified in the United States, through genetic analysis, many rivers are known to support reproducing populations. Early life stage Atlantic sturgeon coupled with upstream movements of adults suggest spawning adults generally migrate upriver in the spring/early summer; February-March in southern systems, April-May in mid-Atlantic systems, and May-July in Canadian systems (Smith 1985, Bain 1997, Smith and Clugston 1997, Kahnle *et al.* 1998). Atlantic sturgeon spawn in freshwater, but spend most of their adult life in the marine environment. Some rivers may also support a fall spawning migration.

Sub-adult and adult Atlantic sturgeon undertake long marine migrations and utilize habitat up and down the East Coast for rearing, feeding, and migrating (Dovel and Berggren 1983, Bain 1997, Stevenson 1997). These migratory sub-adults, as well as adults, are normally located in shallow (10-50m) near shore areas dominated by gravel and sand substrate (Stein *et al.* 2004). Tagging and genetic data indicate that sub-adult and adult Atlantic sturgeon may travel widely once they emigrate from rivers. Once in marine waters, sub-adults undergo rapid growth (Dovel and Berggren 1983, Stevenson 1997). Despite extensive mixing in coastal waters, Atlantic sturgeon display high site fidelity to their natal streams. Straying between rivers within a proposed DPS would sometimes exceed 5 migrants per generation, but between DPSs was usually less than one migrant per generation, with the exception of fish from the Delaware River straying more frequently to southern rivers (Grundwald *et al.* 2008).

Atlantic sturgeon have been aged to 60 years (Mangin 1964); however, this should be taken as an approximation because the age validation studies conducted to date show ages cannot be reliably estimated after 15-20 years (Stevenson and Secor 1999). Vital parameters of sturgeon populations generally show clinal variation with faster growth, earlier age at maturation, and shorter life span in more southern systems. Spawning intervals range from one to five years for male Atlantic sturgeon (Smith 1985, Collins *et al.* 2000, Schueller and Peterson 2010) and three to five years for females (Vladykov and Greely 1963, Stevenson and Secor 1999, Bain 2002, Schueller and Peterson 2010). Fecundity of Atlantic sturgeon has been correlated with age and body size (ranging from 400,000 – 8 million eggs) (Smith *et al.* 1982, Van Eenennaam and Doroshov 1998, Dadswell 2006). The average age at which 50% of maximum lifetime egg production is achieved estimated to be 29 years, approximately 3-10 times longer than for other bony fish species examined (Boreman 1997).

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (e.g., cobble) (Gilbert 1989; Smith and Clugston 1997). Hatching occurs approximately 94-140 hrs after egg deposition, and larvae assume a demersal existence (Smith *et al.* 1980). The yolksac larval stage is completed in about 8-12 days, during which time the larvae move downstream to rearing grounds over a 6 – 12 day period (Kynard and Horgan 2002). During the first half of their migration downstream, movement is limited to night. During the day, larvae use benthic structure (e.g., gravel matrix) as refugia (Kynard and Horgan 2002). During the latter half of migration when larvae are more fully developed, movement to rearing grounds occurs both day and night. Juvenile sturgeon continue to move further downstream into brackish waters, and eventually become residents in estuarine waters for months or years.

Most Atlantic sturgeon managers and researchers consider water quality as a moderate risk to every DPS in the United States (ASSRT 2007). During all stages of development, Atlantic sturgeon are sensitive to temperatures above 28°C (Niklitschek and Secor 2005, Kahn and Mohead 2010, Niklitschek and Secor 2010) and dissolved oxygen levels below 4.3 to 4.7 parts per million (Secor and Niklitschek 2002, EPA 2003, Niklitschek and Secor 2009a). Juvenile sturgeon are also stressed by high salinities until they mature and out migrate. Additionally, sturgeons generally and Atlantic sturgeon specifically are sensitive to pesticides, heavy metals, and other toxins in the aquatic environment.

Status and trends of Atlantic sturgeon populations. Prior to 1890, Atlantic sturgeon populations were at or near carrying capacity. In the mid-1800s, incidental catches of Atlantic sturgeon in the shad and river herring haul seine fisheries indicated that the species was very abundant (reviewed in Armstrong and Hightower 2002). A major fishery for this species did not exist until 1870 when a caviar market was established (reviewed in Smith and Clugston 1997). Record landings were reported in 1890, where over 3350 metric tons (mt) of Atlantic sturgeon were landed from coastal rivers along the Atlantic Coast (reviewed in Smith and Clugston 1997, Secor and Waldman 1999). Between 1890 and 1905, Atlantic sturgeon (and shortnose sturgeon) populations were drastically reduced for sale of meat and caviar. Between 1920 and 1998, the harvest level remained very low due to small remnant populations. The majority of these landings (75%) were dominated by the Delaware River fishery, which presumably supported the largest population along the Atlantic Coast (reviewed in Secor and Waldman 1999). Prompted by research on juvenile production between 1985 and 1995 (Peterson *et al.* 2000), the Atlantic sturgeon fishery was closed by the Atlantic States Marine Fisheries Commission in 1998, when a coastwide fishing moratorium was imposed for 20 to 40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (ASMFC 1998).

Ten years after peak landings, the fishery collapsed in 1901, when less than 10% (295 mt) of its 1890 peak landings were reported. The landings continued to decline to about 5% of the peak until 1920 and have remained between 1-5% since then. During the 1950s, the remaining fishery switched to targeting sturgeon for flesh, rather than caviar. The Atlantic sturgeon fishery was closed by the Atlantic States Marine Fisheries Commission in 1998, when a coastwide fishing moratorium was imposed for 20-40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (ASMFC 1998).

Since the closure of the Atlantic sturgeon fishery, the only assessments of adult spawning populations have been made in the Hudson and Altamaha Rivers. While Atlantic sturgeon have been captured, tagged, and tracked through estuaries and rivers along the East Coast, no other estimates of spawning run size or juvenile population sizes have been made. Making estimates of spawning adults relies on the assumptions that 1) all adults that migrate into the freshwater portion of a river are native to that river and 2) are making that upstream migration with the intention of spawning. Kahnle *et al. (*2007) reported that approximately 870 adults per year returned to the Hudson River between 1985 and 1995. Peterson *et al.* (2008) reported that approximately 324 and 386 adults per year returned to the Altamaha River in 2004 and 2005, respectively.

Juvenile Atlantic sturgeon abundance may be a more precise way to measure the status of Atlantic sturgeon populations because it is believed that all age-1 and age-2 juveniles are restricted to their natal rivers (Dovel and Berggren 1983, Bain *et al.* 1999), avoiding the assumptions noted above. Peterson *et al.* (2000) reported that there were approximately 4,300 age-1 and -2 Atlantic sturgeon in the Hudson River between 1985 and 1995. Schueller and Peterson (2010) reported that age-1 and -2 Atlantic sturgeon population densities ranged from 1,000 to 2,000 individuals over a 4 year period from 2004 to 2007. Other spawning populations within the U.S. are predicted to have fewer than 300 adults spawning per year.

As alluded to above, no current population estimates exist for Atlantic sturgeon DPSs or rivers. The examination of spawning adult abundance estimates, juvenile abundance estimates, and informative qualitative information can provide river-specific information such as trends, evidence of spawning, or documentation of multiple year classes. Atlantic sturgeon occur as relatively distinct populations by river system (Quattro *et al.* 2002; Wirgin *et al.* 2000) with possible metapopulations existing as well. Knowing this information, one can examine each river population within each DPS to get an idea of possible abundance.

Hudson and Altamaha River Spawning Adult Estimates. As stated above, the Hudson and Altamaha Rivers have available abundance estimates for per year Atlantic sturgeon spawning adults. The Hudson River is estimated to have 870 spawning adults per year (Kahnle *et al.* 2007) and the Altamaha River is estimated to have 343 spawning adults per year (Schueller and Peterson 2006). Atlantic sturgeon do not spawn each year with studies showing that spawning intervals range from 1-5 years for males (Smith 1985, Collins *et al.* 2000, Caron *et al.* 2002) and 2-5 years for females (Vladykov and Greeley 1963, Van Eenennaam *et al.* 1996, Stevenson and Secor 1999). We can use this information to estimate total spawning adult abundance by obtaining sex ratios from the literature. Sex ratios of spawners collected in freshwater are similar in northern and southern rivers, with 70-75% male and 25-30% female (Van Eenennaam *et al.* 1996, Collins *et al.* 2000, Caron *et al.* 2002). However, this can change depending on the year. For example, no ripe females were captured in the Hudson River during one research study (Mohler and Fletcher 1998). If we utilize the sex ratio percentages found in the literature and also use the Hudson and Altamaha per-year spawning adult abundance estimates, we can calculate that there could be 652 males and 218 females on the spawning grounds each year in the Hudson River. If we know that spawning intervals for males are 1-5 years and spawning intervals for females are 2-5 years, we can use this information to estimate total spawning adults that belong to that population based on the assumption that adults not

spawning that year are off doing something else. This means that if males and females both spawn every 5 years, there would be five times the amount of spawners per year, since those adult cohorts not spawning in a particular year would not be on the spawning grounds for that given year. Therefore, if we take the upper end of the range, and estimate that males do spawn every 5 years and females do spawn every 5 years, this would mean that there could be 3,260 males and 1,090 females (4,350 spawning adults) in the Hudson River population. Using this same upper limit for the Altamaha yields a possible estimate of 1,286 males and 429 females (1,715 spawning adults). If we take the lower end of the range and estimate that males spawn once every year and females spawn once every two years, this would mean that there could be 652 males and 436 females belonging to the Hudson River spawning population, which could total 1,088 spawning adults. If we do this for the Altamaha, this calculation yields 429 spawning adults. Based on these per year spawning adult estimates from the literature combined with the of use sex ratios yields a possible size of 1,088-4,350 spawning adults in the Hudson River and a possible size of 429-1,715 spawning adults in the Altamaha River.

However, there is more to a river population size than looking at its spawning adults. Spawning adult estimates do not consider juveniles, sub-adults, and non-spawning adults, which make up the rest of the population for a given natal river. Simply using the adult spawning numbers underestimates the entire population for a given natal river. To get a better idea of population sizes for the Hudson and Altamaha, we also examined information on abundance estimates for juveniles. Estimates for the Altamaha River reveal juvenile abundance ranging from 1,072 to 2,033 individuals (Schueller and Peterson 2010). Relative abundance sampling in the Hudson River revealed captures of 562 juveniles from October 2003-November 2005 (Sweka *et al.* 2006).

Other populations are believed to have fewer spawning adults than either the Hudson or Altamaha. There are no abundance estimates available to rely on, so qualitative information provides our river-specific information such as trends, evidence of spawning, or documentation of multiple year classes.

Kennebec and Merrimack Rivers. Three hundred and thirty-six Atlantic sturgeon (nine adults and 327 sub-adults) were captured in the Kennebec River in a multi-filament gill net survey conducted intermittently from 1977-2000 (Squiers 2004). During this period, the catch per unit effort (CPUE) of Atlantic sturgeon had increased by a factor of 10-25 (1977 – 1981 CPUE = 0.30 versus 1998 – 2000 CPUE = 7.43).

An intensive gill net survey was conducted in the Merrimack River from 1987-1990 to determine annual movements, spawning, summering, and wintering areas of shortnose and Atlantic sturgeon (Kieffer and Kynard 1993). Thirty six Atlantic sturgeon were captured (70-156 cm total length). Most of these fish were under 100 cm total length, suggesting that these were all sub-adult sturgeon (Kieffer and Kynard 1993).

Hudson River. Besides what was presented above for the Hudson, two estimates of immature Atlantic sturgeon have been calculated for the Hudson River stock, one for the 1976 year class and one for the 1994 year class. Dovel and Berggren (1983) marked immature fish from 1976-1978. Estimates for the 1976 year class at age one ranged from 14,500-36,000

individuals (mean of 25,000). In October of 1994, the New York State Department of Environmental Conservation (NYSDEC) stocked 4,929 marked age-0 Atlantic sturgeon, provided by a U.S. Fish and Wildlife Service (USFWS) hatchery, into the Hudson Estuary at Newburgh Bay. These fish were reared from Hudson River brood stock. In 1995, Cornell University sampling crews collected 15 stocked and 14 wild age-1 Atlantic sturgeon (Peterson *et al.* 2000). A Petersen mark-recapture population estimate from these data suggests that there were 9,529 (95% CI = 1,916 – 10,473) age-0 Atlantic sturgeon in the estuary in 1994. Since 4,929 were stocked, 4,600 fish were of wild origin, assuming equal survival for both hatchery and wild fish and that stocking mortality for hatchery fish was zero.

Hudson River Valley utilities (Central Hudson Electric and Gas Corp., Consolidated Edison Company of New York, Inc., New York Power Authority, Niagara Mohawk Power Corporation, Orange and Rockland Utilities, Inc.) conduct extensive river-wide fishery surveys to obtain data for estimating impacts of power plant operations. Detailed survey descriptions are provided in the utilities' annual reports (CONED 1997). Two surveys regularly catch sturgeon, despite the fact that these surveys were not specifically designed to capture sturgeon. The Long River Survey (LRS) samples ichthyoplankton river-wide from the George Washington Bridge (rkm 19) to Troy (rkm 246) using a stratified random design (CONED 1997). These data, which are collected from May-July, provide an annual index of juvenile Atlantic sturgeon in the Hudson River estuary since 1974. The Fall Shoals Survey (FSS), conducted from July – October by the utilities, calculates an annual index of the number of fish captured per haul. Between 1974 and 1984, the shoals in the entire river (rkm 19-246) were sampled by epibenthic sled; in 1985 the gear was changed to a three-meter beam trawl. Length data are only available for the beam trawl survey from 1989 to the present; fish length ranged from 10 – 100 cm TL, with most fish less than 70 cm TL. Based on these length data, it seems that ages-0 (YOY), 1, and 2 sturgeon are present in the river. Indices from utility surveys conducted from 1974 to the present (LRS and FSS) indicate a trend consistent with NYSDEC American shad monitoring data. Abundance of young juvenile Atlantic sturgeon has been declining, with CPUE peaking at 12.29 in 1986 (peak in this survey) and declining to 0.47 in 1990. Since 1990, the CPUE has ranged from 0.47-3.17, increasing in recent years to 3.85 (2003). In 2000, the NYSDEC created a sturgeon juvenile survey program to supplement the utilities' survey; however, funds were cut in 2000, and the USFWS was contracted in 2003 to continue the program. In 2003 – 2005, 579 juveniles were collected (N = 122, 208, and 289, respectively) (Sweka *et al.* 2006). Pectoral spine analysis showed they ranged from 1 – 8 years of age, with the majority being ages 2 – 6. None of the captures were found to be YOY (< 41 cm TL).

Indices for post-migrant Atlantic sturgeon are provided by the New Jersey Bureau of Marine Fisheries from surveys of the coastal waters along the entire state (Sandy Hook to Delaware Bay). Since 1988 when the survey was initiated, a total of 96 Atlantic sturgeon have been captured.

Abundances of post-migrants seem to be declining as CPUE has decreased from a high of 8.75 in 1989 to 1.5 in 2003. This trend differs from Hudson River Fall Shoals Utility Survey, which indicated an increasing or stable trend over the last several years.
All available data on abundance of juvenile Atlantic sturgeon in the Hudson River estuary (i.e., mark/recapture studies, bycatch data from commercial gill net fishery, and utilities sampling)

indicate a substantial drop in production of young since the mid 1970s. The greatest decline seemed to occur in the middle to late 1970s, followed by a secondary drop in the late 1980s. Sturgeon are still present, and juveniles (age-0 (YOY), 1, and 2 years) were captured in recent years and a slight increasing trend in CPUE has been observed. The capture of YOY sturgeon in 1991, 1993-1996, and 2003, provides evidence of successful spawning.

Connecticut River. From 1984-2000, the Connecticut Department of Environmental Protection (CTDEP) studied the abundance, locations, and seasonal movement patterns of shortnose sturgeon in the lower Connecticut River and Long Island Sound (Savoy and Pacileo 2003). Sampling was conducted using gill nets ranging from 10-18 cm stretched mesh in the lower Connecticut River (1988-2005) and a stratified random-block designed trawl survey (12.8 m 1984-1990 and 15.2 m 1990-2005) in the Long Island Sound (also referred to as the LIS Trawl Survey). One hundred and thirty-one Atlantic sturgeon were collected from the lower Connecticut River gill net survey, and average lengths of fish reported from 1988-2000 were 77 cm FL (51-107 cm FL). The majority of these sub-adult Atlantic sturgeon were captured in the lower river (between rkm 10-26) within the summer range of the salt wedge (Savoy and Shake 1993).

A total of 347 fish were collected in the LIS trawl survey from 1984-2004, of these with reported lengths (1984-2000) the mean length was 105 cm FL (ranging from 63-191 cm FL). Data from 1984-2000, indicated that 68% of the Atlantic sturgeon captured in the trawl survey came from the Central Basin (off Faulkner Island), while 6% of catches occurred in northern portions of the LIS survey near the mouth of the Connecticut River.

Delaware River. The current abundance of all Atlantic sturgeon life stages in the Delaware River has been greatly reduced from the historical level. Brundage and Meadows (1982) recorded 130 Atlantic sturgeon captures between the years of 1958 – 1980. The Delaware Division of Fish and Wildlife (DFW) began sampling Delaware Bay in 1966 by bottom trawl and have rarely captured Atlantic sturgeon. During the period from 1990 to 2004, the trawl survey captured 17 Atlantic sturgeon (Murphy 2005). However, there are several areas within the estuary where juvenile sturgeon regularly occur. Lazzari *et al.* (1986) frequently captured juvenile Atlantic sturgeon from May-December in the upper tidal portion of the river below Trenton, New Jersey (N = 89, 1981 – 1984). In addition, directed gill net surveys by DFW from 1991-1998 consistently took juvenile (N > 1,700 overall) Atlantic sturgeon in the lower Delaware River near Artificial Island and Cherry Island Flats from late spring to early fall (Shirey *et al.* 1999). The number of fish captured in the lower river annually has declined dramatically throughout this time period from 565 individuals in 1991 to 14 in 1998. Population estimates based on mark and recapture of juvenile Atlantic sturgeon declined from a high of 5,600 in 1991 to less than 1,000 in 1995; however, it is important to note that population estimates violated most tagging study assumptions and should not be used as unequivocal evidence that the population has declined dramatically. No population estimates are available from 1996 and 1997, given the low number of recaptures.

In Delaware, gillnet surveys are conducted on the Delaware River by the state's Division of Fish and Wildlife as part of their Atlantic sturgeon research program. Since 1991, more than 2,000 Atlantic sturgeon have been captured and tagged (DNREC 2009). Based on their length, most

are believed to have been sub-adults. In September 2009, however, personnel captured their smallest sturgeon yet; an age 0 fish, which was 178 mm and weighed less than an ounch (DNREC 2009). In all, 34 young-of-year sturgeon were caught during the sampling period (September 9 – November 9, 2009), ranging in size from 178 to 349 mm total length (Fisher 2009). These captures provide evidence that successful spawning is still occurring in the Delaware River.

Chesapeake Bay. A Virginia Institute of Marine Science (VIMS) trawl survey was initiated in 1955 to investigate finfish dynamics within the Chesapeake Bay; the survey was standardized in 1979. Since 1955, 40 Atlantic sturgeon have been captured, 16 of which were captured since 1990, and two of these collections may have been young of year (YOY) based on size. No fish were captured between 1990 and 1996; however, seven were captured in 1998. In subsequent years, catch declined ranging between zero and three fish per year. Similarly, American shad monitoring programs (independent stake gill net survey) also recorded a spike in Atlantic sturgeon bycatch that peaked in 1998 (N = 34; 27 from James River) and declined dramatically in later years to only one to three sturgeon being captured in each year from 2002-2004. These observations could be biased by stocking 3,200 juveniles in the Nanticoke River in 1996; however, the capture of wild fish in the Maryland Reward Tagging program conducted from 1996 to present shows identical rates of capture for wild fish.

The Maryland reward tagging program has resulted in the capture of 1,700 Atlantic sturgeon. Five hundred and sixty seven of these fish were hatchery fish, of which 462 were first time captures (14% recapture rate), the remaining captures (1,133) were wild. However, none of these 1,700 Atlantic sturgeon were considered YOY based on length data (S. Minkkinen, USFWS, Pers. Comm. 2006). Similarly, Virginia initiated a reward tagging program in 1996 18 through 1998. The majority of their recaptures were wild Atlantic sturgeon taken from the lower James and York rivers in the 20 – 40 cm size range and are believed to be YOY (A. Spells, USFWS, Pers. Comm. 1998). Captures of YOY and age-1 sturgeon in the James River during 1996 and 1997 suggest spawning has occurred in that system.

Since then, captures from the reward program have varied, declining from 1999 to 2002 and then increasing in 2005 to levels similar to that of 1998 and with record levels during 2006. Further evidence that spawning may have occurred recently is provided by three carcasses of large adults found in the James River in 2000-2003, the discovery of a 213 cm carcass of an adult found in the Appomattox River in 2005, as well as the release of a 2.4 m Atlantic sturgeon near Hoopers Island (the Bay) in April, 1998 (S. Minkkinen, USFWS, Pers. Comm. 2006).

Within the Chesapeake Bay, the FWS has been funding the Maryland Reward Program since 1996. This program has resulted in the documentation of approximately 1,700 Atlantic sturgeon. Five hundred sixty seven of these fish were hatchery fish, of which 462 were first time captures (14% recapture rate), and the remaining 1,133 were wild fish.

Virginia also instituted an Atlantic sturgeon reward program in the Chesapeake Bay in 1997 and 1998 (ASSRT 2007). This reward program documented and measured 295 Atlantic sturgeon. Data collected during the reward program documents the presence of young of year fish. Such data include length information which shows that 18.6% (55 of 295 measured) of the fish caught

were within the 20 to 40 cm fork length size class (A. Spells, FWS, pers. Comm., 2008). In addition, aging of fish spines collected from fish suggested that 34% were age 1 (A. Spells, FWS, pers. Comm., 2008). This information is important in that it strongly suggests the presence of spawning in one or more rivers that flow into the Bay. Further evidence of Atlantic sturgeon spawning in the Chesapeake Bay area is provided by three carcasses of large adults found in the James River in 2000-2003; the discovery of a 213 cm TL carcass of an adult found in the Appomattox River in 2005; the capture and release of a 240 cm TL Atlantic sturgeon near Hoopers Island, MD in April, 1998 (S. Minkkinen, FWS, pers. comm., 2006); documentation of a gravid adult female Atlantic sturgeon off Tilghman Island, MD in April,
(the first gravid female documented in the Maryland portion of the Chesapeake Bay since the early 1970s); and the capture of several males producing milt in the James River in 2007 and 2008 (A. Spells, FWS, pers. comm.).

Roanoke River/Albemarle Sound. Historic and current survey data indicate that spawning occurs in the Roanoke River/Albemarle Sound system, where both adults and small juveniles have been captured. Since 1990, the North Carolina (NC) Division of Marine Fisheries (NCDMF) has conducted the Albemarle Sound Independent Gill Net Survey (IGNS), initially designed to target striped bass. The survey is conducted from November-May, using a randomized block sampling design and employing 439 m of gill net, both sinking and floating, with stretched mesh sizes ranges from 63.5 mm (2.5 in) to 254 mm (10 in). Since 1990, 842 sturgeon have been captured ranging from 15.3 to 100 cm FL, averaging 47.2 cm FL. One hundred and thirty-three (16%) of the 842 sturgeon captured could be classified as YOY ($\leq$ 41 cm TL, $\leq$ 35 cm FL); the others were sub-adults. Incidental take of Atlantic sturgeon in the IGNS indicate that the subpopulation has been increasing in recent years (1990-2000), but since then recruitment has dramatically declined. Similarly, the NCDMF Observer Program documented the capture of 30 Atlantic sturgeon in large and small mesh gill nets; two of these individuals being YOY (< 410 mm TL) (Blake Price, NCDMF, Pers. Comm. 2006).

In 1997 and 1998, NC State University (NCSU) researchers characterized the habitat use, growth, and movement of juvenile Atlantic sturgeon (Armstrong and Hightower 2002). Their survey collected 107 Atlantic sturgeon, of which 15 (14%) could be considered YOY ($\leq$ 41 cm TL or 35 cm FL). Young juveniles were observed more often over organic rich mud bottoms and at depths of 3.6-5.4 meters. Adult running ripe sturgeon have not been collected in the

Roanoke River even though the NC Wildlife Resources Commission has sampled the spawning grounds since the 1990s during their annual striped bass electrofishing survey.

However, in 2005, an angler captured a YOY (39 cm TL) Atlantic sturgeon in the Roanoke River, near the city of Jamesville, NC. These multiple observations of YOY from the Albemarle Sound and Roanoke River provide evidence that spawning continues, and catch records indicate that this population seemed to be increasing until 2000, when recruitment began to decline.

Pamlico Sound (Tar and Neuse Rivers) – North Carolina. Evidence of spawning was reported by Hoff (1980), who noted captures of very young juveniles in the Tar and Neuse rivers. More recently, two juveniles (approximately 45 and 60 cm TL) were observed dead on the bank of Banjo Creek, a tributary to the Pamlico system (B. Brun, USFWS and US Army Corps of

Engineers (retired), Pers. Comm. 1998). An independent gill net survey, following the Albemarle Sound IGNS methodology, was initiated in 2001. Collections were low during the periods of 2001-2003, ranging from zero to one fish/yr. However, in 2004, this survey collected 14 Atlantic sturgeon ranging from 460 to 802 mm FL, and averaging 575 mm FL. During the same time period (2002 – 2003), four Atlantic sturgeon (561 – 992 mm FL) were captured by NCSU personnel sampling in the Neuse River (Oakley 2003). Similarly, the NCDMF Observer Program documented the capture of 12 Atlantic sturgeon in the Pamlico Sound from April 2004 to December 2005; none of these were YOY or spawning adults, averaging approximately 600 mm TL (Blake Price, NCDMF, Pers. Comm. 2006).

Cape Fear River – North Carolina. A gill net survey for adult shortnose and juvenile Atlantic sturgeon was conducted in the Cape Fear River drainage from 1990-1992, and replicated 1997-2005. Each sampling period included two overnight sets (checked every 24 hrs). The 1990-1992 survey captured 100 Atlantic sturgeon below Lock and Dam #1 (rkm 95) for a CPUE of 0.11 fish/net-day. No sturgeon were collected during intensive sampling above Lock and Dam #1. In 1997, 16 Atlantic sturgeon were captured below Lock and Dam #1, an additional 60 Atlantic sturgeon were caught in the Brunswick (a tributary of the Cape Fear River), and 12 were caught in the Northeast Cape River (Moser *et al.* 1998). Relative abundance of Atlantic sturgeon below Lock and Dam #1 seemed to have increased dramatically since the survey was conducted in 1990-1992 (Moser *et al.* 1998) as the CPUE of Atlantic sturgeon was two to eight times greater during 1997 than in the earlier survey.

Since 1997, Atlantic sturgeon CPUE has been gradually increasing: a regression analysis revealed that CPUE doubled between the years of 1997 (~0.25 CPUE) and 2003 (0.50 CPUE) (Williams and Lankford, 2003). This increase may reflect the effects of North Carolina's ban on Atlantic sturgeon fishing that began in 1991; however, the increase in CPUE may also be artificial as these estimates are similar among years except in 2002 (large increase) that likely skewed the regression analysis. In 2003, the NCDMF continued the sampling program (Cape Fear River Survey) and have collected 91 Atlantic sturgeon (427 - 1473 mm FL).

South Carolina Rivers. More than 3,000 juveniles (years 0-1) have been collected and tagged in South Carolina rivers since 1994 (McCord *et al.* 2007). In 1998, the same researchers (working with local fishermen) captured only 39 fish in 13 nominal age-classes (McCord *et al.* 2007). In another South Carolina river, two years of sampling captured 31 juvenile Atlantic sturgeon (McCord *et al.* 2007).

Winyah Bay (Waccamaw, Great Pee Dee, and Sampit Rivers) – South Carolina. Recent shortnose sturgeon sampling (using 5, 5.5, 7, and 9 inch stretched mesh experimental gill nets; 16' otter trawl) conducted in Winyah Bay captured two sub-adult Atlantic sturgeon during 4.2 hrs of effort in 2004. Captures of age-1 juveniles from the Waccamaw River during the early 1980s suggest that a reproducing population of Atlantic sturgeon may persist in that river, although the fish could have been from the nearby Great Pee Dee River (Collins and Smith 1997). In 2003 and 2004, nine Atlantic sturgeon (48.4-112.2 cm FL) were captured in the Waccamaw River during the South Carolina (SC) Department of Natural Resources (SCDNR) annual American shad gill net survey, although none were considered spawning adults or YOY.

However, Collins *et al.* (1996) note that unlike northern populations, in South Carolina, YOY are considered to be less than 50 cm TL or 42.5 cm FL, as growth rates are greater in the warmer southern waters compared to cooler northern waters. Therefore, the capture of a 48.4 cm fork length (FL) sturgeon provides some evidence that YOY may be present in the Waccamaw River and some evidence of a spawning subpopulation. Lastly, watermen on the lower Waccamaw and Pee Dee rivers have observed jumping sturgeon, which suggest that rivers either serve as a nursery/feeding habitat or support an extant subpopulation(s) (W. Laney, USFWS, Pers. Comm. 2007).

Santee and Cooper Rivers – South Carolina. The capture of 151 sub-adults, including age-1 juveniles, in the Santee River in 1997 suggests that an Atlantic sturgeon population exists in this river (Collins and Smith 1997). This is supported by three adult Atlantic sturgeon carcasses found above the Wilson and Pinopolis dams in Lakes Moultrie (Santee-Cooper reservoirs) during the 1990s (M. Collins, SCDNR, Pers. Comm. 2006). Although shortnose sturgeon spawning above the dam has been documented, there is scant information to support existence of a land-locked subpopulation of Atlantic sturgeon. In 2004, 15 sub-adult Atlantic sturgeon were captured in shortnose sturgeon surveys during 156.6 hrs of effort conducted in the Santee estuary. The previous winter, four juvenile (YOY and sub-adults) Atlantic sturgeon were captured (360 – 657 mm FL) from the Santee (N =1) and Cooper (N = 3) rivers. These data support previous hypotheses that a fall spawning run occurs within this system, similar to that observed in other southern river systems. However, SCDNR biologists are skeptical as to whether these smaller sturgeon (360 and 378 mm FL) from the Santee-Cooper are resident YOY as flood waters from the Pee Dee or Waccamaw River could have transported these YOY to the Santee-Cooper system via Winyah Bay and the Intercoastal Waterway (ICW) (McCord 2004).

ACE Basin (Ashepoo, Combahee, and Edisto Rivers) – South Carolina. From 1994 - 2001, over 3,000 juveniles have been collected in the ACE Basin including 1,331 YOY sturgeon (Collins and Smith 1997, M. Collins, SCDNR, Pers. Comm. 2005). Sampling for adults began in 1997, with two adult sturgeon captured in the first year of the survey, including one gravid female (234 cm TL) captured in the Edisto River and one running ripe male (193 cm TL) captured in the Combahee River. The running ripe male in the Combahee River was recaptured one week later in the Edisto River, which suggests that the three rivers that make up the ACE basin may support a single subpopulation that spawns in at least two of the rivers. In 1998, an additional 39 spawning adults were captured (M. Collins, SCDNR, Pers. Comm. 2006). These captures show that a current spawning subpopulation exists in the ACE Basin as both YOY and spawning adults are regularly captured.

Savannah River – South Carolina and Georgia. The Savannah River supports a reproducing subpopulation of Atlantic sturgeon (Collins and Smith 1997). According to the NOAA National Ocean Service, 70 Atlantic sturgeon have been captured since 1999 (J. Carter, NOS, supplemental data 2006). Twenty-two of these fish have been YOY (< 410 mm TL). A running ripe male was captured at the base of the dam at Augusta during the late summer of 1997, which supports the hypothesis that spawning occurs there in the fall.

Ogeechee River – Georgia. Previous studies have shown the continued persistence of Atlantic sturgeon in this river, as indicated by the capture of age +1 fish. Sampling efforts

(including 1991-1994, 1997 and 1998) to collect age-1 sturgeon as part of the Savannah River genetics study suggest that juvenile abundance is rare with high inter-annual variability, indicating spawning or recruitment failure. However, the Army's Environmental and Natural Resources Division (AENRD) at Fort Stewart, Georgia, collected 17 sturgeon in 2003 considered to be YOY (less than 30 cm TL) and an additional 137 fish in 2004, using a 30 m x 2 m experimental gill net (3.8, 7.7, 12.7, 15.2, 17.8 cm stretched mesh). Most of these fish were juveniles; however, nine of these fish measured less than 41 cm total length (TL) and were considered YOY. In 2003, 17 sturgeon captured in this survey were also considered YOY (reported as less than 30 cm TL). The AENRD survey provides the most recent captures of YOY in the Ogeechee.

Altamaha River – Georgia. The Altamaha River supports one of the healthiest Atlantic sturgeon subpopulations in the Southeast, with over 2,000 sub-adults captured in trammel nets, 800 of which were nominally age-1 as indicated by size. Independent monitoring of the American shad fishery also documents the incidental take of Atlantic sturgeon within the river. Using these data, the subpopulation does not seem to be increasing or decreasing, as catch trends are variable.

A survey targeting Atlantic sturgeon was initiated in 2003 by the University of Georgia. Trammel nets (91 m x 3 m) and gill nets were set in the lower 27 rkm of the Altamaha River, and were fished for 20-40 minutes during slack tides only. Sampling for adults was conducted using large mesh-gill nets set by local commercial fishermen during the months of April through May 2003. During 2005, similar gill nets were drift set during slack tides to supplement catches. As of October 2005, 1,022 Atlantic sturgeon have been captured using these gear types (trammel and large gill nets). Two hundred and sixty seven of these fish were collected during the spring spawning run in 2004 (N = 74 adults) and 2005 (N = 139 Adults). From these captures, 308 (2004) and 378 (2005) adults were estimated to have participated in the spring spawning run, which is 1.5% of Georgia's historical spawning stock (females) that were estimated from U.S. Fish Commission landing records (Schueller and Peterson 2006, Secor 2002).

St. Johns River – Florida. In the 1970s and 1980s, there were several reports of Atlantic sturgeon being captured by commercial fishermen, although these fish were considered juveniles measuring 69 – 84 cm in length (J. Holder, Florida Fish and Wildlife Commission, Pers. Comm. 2006). There have been reports of Atlantic sturgeon tagged in the Edisto River (South Carolina) having been recaptured in the St. Johns River, indicating this river may serve as a nursery ground; however, there are no data to support the existence of a spawning subpopulation (i.e., YOY or running ripe adults) (Rogers and Weber 1995, Kahnle *et al.* 1998).

Past Catch by Atlantic sturgeon Researchers in All Areas. Although research projects change from year to year, a look at researchers' past catch can yield valuable qualitiative information about Atlantic sturgeon in certain areas. Since all permits proposed in this Opinion are supervised by Principal Investigators who are at the forefront of the field in Atlantic sturgeon research, a look at their past catch can yield important information about availability of Atlantic sturgeon in the action area (Table 20). Some of these figures are expressed as estimates due to the fact that Atlantic sturgeon were unlisted at the time of capture and, thus, less accurate reporting occurred.

Table 20. Historical catch and mortality of Atlantic sturgeon reported by researchers prior to listing. (juvenile and/or adults, ELS)

Researchers Associated File No.	Associated DPS Location	Total Estimated Catch Annually	Reported Incidental Mortality
16526	**GOM** (Merrimack River, Kennebec Complex, Penobscot and other coastal rivers)	~120	4 Juv (Over 5 years)
16323	**New York Bight** (LI Sound & CT River)	~200	0
16422	**New York Bight** (LIS, NY & NJ Coast)	~300 (In 2010)	0
16436	**New York Bight** (Hudson River)	~200	1 Adult (Over 5 Years)
16438	**New York Bight** Delaware River	~60	3 Juv (Over 5Years
16507	**New York Bight** (Delaware River & Coast)	~375(Total as of 2004)	3 Sub-adults (In 2009)
16431	**New York Bight** (Delaware River)	~100	3 Juv (Over 5 Years)
16547	**Chesapeake Bay** (Bay and Tributaries)	~250	2 sub-adults annually
16375	**Carolina** (North Carolina Rivers)	28	0
16442	**Carolina and South Atlantic** (SC Rivers)	~80	0
16482	**South Atlantic** (Georgia Rivers & Coast)	~2,400	~5 juv annually
16508	**South Atlantic** (Florida/Georgia Rivers)	N.A.	N.A.

Listing status

A petition to list the Atlantic sturgeon was submitted in 1997. After a status review, it was determined that the species did not merit listing under the Endangered Species Act (ESA) at that time. In 2003, a workshop sponsored by NMFS and U.S. Fish and Wildlife Service was held to review the status of Atlantic sturgeon. The workshop attendees concluded that some populations seemed to be recovering while other populations continued to be depressed. As a result, NMFS initiated a second status review of Atlantic sturgeon in 2005 to reevaluate whether this species required protection under the ESA. That status review was completed in 2007 (ASSRT 2007).

Currently, five DPSs of Atlantic sturgeon are listed under the ESA. The Gulf of Maine DPS is listed as threatened while the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered (77 FR 5880 and 77 FR 5914). No critical habitat has been proposed.

VI. ENVIRONMENTAL BASELINE

Northeast Atlantic Region

This region encompasses Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland and Virginia. The region is ecologically diverse, encompassing several broad ecoregions—according to Bailey's (1995) *Description of the Ecoregions of the United States* this region encompasses the warm continental, the hot continental and the hot continental mountains divisions —these ecoregions can be further subdivided into provinces based on vegetation (Bailey 1995). This region encompasses the New England/Acadian mixed forests and the Northeastern Coastal Forests. The headwaters of the Connecticut River originate in New England/Acadian forests, and as the river descends, it

transitions from boreal forest to temperate deciduous forest. As the river flows through the low gradient coastal region, the ecoregion transitions to Northeastern Coastal Forest. The headwaters of the Hudson River flow through Eastern Forest/Boreal Transition ecoregions. As the river descends, it transitions to Eastern Great Lakes Lowland Forest and then Northeastern Coastal Forest. The headwaters of the Delaware River originate in the Allegheny Highland Forest ecoregion, and then as the river descends, it transitions to Appalachian/Blue Ridge Forest and then Northeastern Coastal Forest ecoregions.

In this section, we describe several basins and estuarine complexes to characterize the general ecology and natural history of the area, and past and current human activities and their impacts on the area. In certain instances we described some river basins in further detail to provide additional context for evaluating the influence of the environmental baseline on listed species under NMFS' jurisdiction and the health of the environment.

New England Drainages

Natural History. This region encompasses drainages entering the Gulf of Maine, and encompasses all of Maine, parts of New Hampshire, Massachusetts the Canadian provinces of New Brunswick and Nova Scotia. Characterized by a temperate climate and a rocky coastline, the greater Gulf of Maine encompasses the Bay of Fundy, Casco Bay, Massachusetts Bay, Merrymeeting Bay and Cape Cod Bay. Significant Rivers that drain into the Gulf of Maine include the St. John, St. Croix, Penobscot River Basin, Kennebec/Androscoggin River Basin and the Merrimack River Basin. Estuaries within the Gulf of Maine were formed by glaciers and as a result have characteristically rocky shorelines, shallow soils, and deeply carved channels. The Gulf of Maine is semi-enclosed—bounded to the south by Georges Banks and to the north by Brown's Bank. The area is more strongly influenced by the Labrador Current, which makes the waters significantly colder and more nutrient rich than waters to the south that are more strongly influenced by the Gulf Stream.

The cold waters of the Gulf make it one of the most productive marine ecosystems in the world. The Gulf is characterized by salt marshes, kelp and seagrass beds, tidal mudflats, and underwater rocky outcrops form the foundation of a complex ecosystem and provide habitat for Atlantic herring (*Clupea harengus*), American lobster (*Homarus americanus*), Atlantic salmon, several whale species including endangered Northern right whales—where they are regularly observed in the spring and summer at regular nursery and feeding areas.

Penobscot River Basin

The Penobscot River flows 275 miles to the ocean, with the largest watershed in Maine of 8,592 square miles (mi^2) (Jackson *et al.* 2005). The river flows from the mountains of western Maine, including Maine's highest peak, Mt. Katahdin to the ocean near the town of Bucksport, Maine. The Penobscot basin was formed by glaciation during the last ice age and the river's bed is composed of glacial deposits and granitic bedrock. The average precipitation is approximately 42 inches per year. At the mouth, the average discharge is 10.1 billion gallons each day, or 14,000 cubic feet per second, but the discharge fluctuates seasonally and with dam releases, with naturally higher flows in the spring (Hasbrouck 1995, MaineRivers 2007a). The river and

estuary are also important for many fish species, with 45 freshwater and 39 salt water species having been recorded in the river or estuary. Despite being home to so many fish, there are only three nonnative species (Baum 1983, Jackson *et al.* 2005). The Penobscot estuary extends from Bangor downstream to Penobscot Bay in the Gulf of Maine, approximately 31 miles, making it the largest estuary in Maine and one of the largest on the East Coast (PEARL 2007). Downstream of Bangor, the river is a tidally influenced, salt-wedge estuary. The majority of the estuary is bedrock-based, and sediment deposits are limited to isolated coves and near marshes.

Merrymeeting Bay Drainages

Merrymeeting Bay is the largest, freshwater tidal estuary, approximately 18.6 miles upstream of the mouth of the estuary that enters the Gulf of Maine (Kistner and Pettigrew 2001, Jackson *et al.* 2005). The Kennebec and Androscoggin Rivers, along with four smaller tributaries, converge to form the bay, although the two large rivers account for 98% of the inflow. Merrymeeting Bay typically has the largest freshwater outflow to the Gulf of Maine, usually exceeding 15,000 cubic feet per second. These high flows thoroughly flush the bay and have prevented eutrophication. The bay substrate is mud, sand, and exposed bedrock.

In Merrymeeting Bay, sampling only sandy substrate, which doesn't hold as much contaminant as muddy substrates due to less surface area, some toxic substances were identified. Sediments associated with the Androscoggin River had higher levels of PAHs and mercury, while sediments from the Kennebec River had higher levels of chromium, arsenic, and selenium (Hayden 1998). The bay has more moderate levels of these toxins than the rivers themselves. Chilcote and Waterfield (1995) found that levels of arsenic are higher than levels identified by EPA as likely to have adverse effects. At one station, PAHs from the Androscoggin also exceeded EPA identified levels of minimal effects. In this region of the Gulf of Maine, metal deposition is linked more to the Androscoggin and Kennebec than the Sheepscot River. Based on benthic samples taken in 1980 and again in 1991, it appears that all metals are declining in Merrymeeting bay except for copper, which showed an increase (Hayden 1998). Commercially important fish also have elevated metal concentrations in their livers, which is thought to be from their time spent in Merrymeeting Bay (Kirtner and Pettigrew 2001).

The Kennebec River flows 230 miles from the headwaters to the ocean, with a watershed of 5,384 mi^2 (Jackson *et al.* 2005, MaineRivers 2007b). The Kennebec River basin is primarily medium to coarse sand with some glacial till overlaying bedrock. Average precipitation is 42.5 inches of rain per year (Jackson *et al.* 2005). The average discharge at the mouth of the Kennebec River is 5,893 million gallons per day, with natural and controlled discharges similar to those seen on other Maine rivers (MaineRivers 2007b). There are 48 species of freshwater fish that use the Kennebec, including 10 nonnative species.

The Androscoggin River travels 164 miles, with a watershed of 3,263 mi^2 (Jackson *et al.* 2005, MaineRivers 2007c). The river flows from northwest Maine, into New Hampshire, and then back into Maine, where it meets the Kennebec River in Merrymeeting Bay. The Androscoggin has been Maine's principle industrial river (MaineRivers 2007c). The average precipitation in the watershed is 43.7 inches per year, resulting in an average discharge at the mouth of the Androscoggin, entering Merrymeeting Bay, of approximately 4,190 million gallons each day.

The river is home to 33 freshwater fish and 7 estuarine fish, including 8 nonnative species (Jackson *et al.* 2005).

Merrimack River Basin

The Merrimack River is 180 miles long, with 16 sub-basins in a watershed of 5,014 mi^2 (Jackson *et al.* 2005, MRWCI 2007a). Seventy five percent of the watershed is in New Hampshire, with the rest in northeast Massachusetts. The precipitation is approximately 36 inches per year, with an average discharge of 5,364 million gallons per day, or 8,299 cubic feet per second. The geology of the Merrimack is dominated by granitic bedrock. The river is home to 50 species of fish, including 5 nonnative species (Jackson *et al.* 2005). For the lowest nine miles of the Merrimack River, extending north into New Hampshire and south to Cape Ann, Massachusetts, there are 25,000 acres of estuarine habitat and 15,000 acres of salt marsh habitat, which is referred to as the Great Marsh (USGS 2003).

Human Activities and Their Impacts

Land Use

Most of the watersheds within this region are heavily forested with relatively small areas of highly urbanized lands. Land use in the Penobscot watershed is 5% agriculture and 95% forest and wetland (90% forest and forested wetlands). There are approximately 21 people per square mile living in the Penobscot watershed, and the largest town is Bangor, consisting of 33,000 people (Jackson *et al.* 2005). While there is not much urban development in the watershed, Doggett and Sowles (1989) report tanneries, metal finishing, pulp and paper mills, textile plants, chemical products, and municipal sewage contribute chromium, mercury, zinc, copper, lead, arsenic, hydrocarbons, dioxins, PAHs, pesticides, and other contaminants to the river.

The Kennebec River watershed usage is 82% forest, 10% water, 6% agriculture, 2% developed (Jackson *et al.* 2005). The only major town in the watershed is Augusta, Maine, but there are approximately 39 people per square mile throughout the watershed (Jackson *et al.* 2005). Currently, the primary pollution source on the river is from two pulp and paper mills, but there were multiple historical polluters along the river. The river exceeds recommended levels of dioxins, arsenic, cadmium chromium, copper, lead, mercury, nickel, silver, zinc, and PAHs in the sediments and surface water (MDEP 1999, Harding Lawson Associates 1999, Harding Lawson Associates 2000). Since 1990, the levels of dioxins in other rivers in Maine have been decreasing, but the levels in the Kennebec have remained constant (Kahl 2001).

The Androscoggin River watershed usage is 5% agriculture, 86% forested, 7% water, and 2% developed (Jackson *et al.* 2005). Major towns in the Androscoggin watershed are Auburn, Lewiston, and Brunswick. The human population in the watershed is approximately 65 people per square mile (Jackson *et al.* 2005). Throughout the 20th century, textile mills, paper and pulp mills, and municipalities contributed large quantities of pollutants to the river. At one time it was considered one of the 10 most polluted rivers in the country and was one of the reasons for the implementation of the Clean Water Act. The river has become much cleaner since the CWA was passed, but pesticides, mercury, lead, sedimentation, total suspended solids, PCBs, and dioxins are still considered too high (Chamberland *et al.* 2002).

The Merrimack River watershed is composed of 75% forest, 13% urban, 6% agriculture, 5% surface water, and 1% other (Jackson *et al.* 2005). The Merrimack River flows through industrial centers Manchester and Concord, New Hampshire, and Lowell and Lawrence, Massachusetts. There are approximately 404 people per square mile in the Merrimack watershed (Jackson *et al.* 2005). The biggest sources of pollution facing the river are combined sewage overflows, industrial discharge, urbanization and its associated run-off (USACE 2003). The upper mainstem of the river has problems with bacteria, E. coli, and acidity, while the lower mainstem has problems with bacteria, metals, nutrients, dioxins, turbidity and suspended solids, and un-ionized ammonia. In all, over 125 miles of mostly lower watershed areas do not support their designated uses (USACE 2003).

Hydromodification Projects

There are five major hydroelectric dams along the mainstem of the Penobscot River as well as 111 other licensed dams located along the river and its tributaries. Atlantic salmon historically migrated as far as 143 miles upstream of the mouth, but due to development along the river, in the 1960s, Atlantic salmon were extirpated (Jackson *et al.* 2005). The population has since been re-established and runs of 2,000 to 4,000 occur with natural spawning as far upstream as 62 miles. Unfortunately, 6,000 to 10,000 salmon are required for a sustainable population, so the Penobscot run depends on fish from a local hatchery (Moore and Platt 1996).

The Kennebec River has eight large hydroelectric dams on its mainstem, which restricts fish passage both up and downstream. In 1999, the Edwards Dam was removed, opening 17 additional miles of habitat for fish and macroinvertebrates in the river. Removal of Edwards dam restored full access to historical spawning habitat for species like Atlantic sturgeon, shortnose sturgeon, and rainbow smelt, but not for species like alewife, American shad, and Atlantic salmon that migrated much further up the river. Since the removal of Edwards Dam, DO levels and macroinvertebrate density have improved. Additionally, in 2007, the fish passage facilities on the lowest dam on the Kennebec River as well as the second and third lowest dams on the Sebasticook River became operational. The lowest dam on the Sebasticook River has been decommissioned and may be breached in as early as 2007 (MDMR 2007).

The Androscoggin River has 14 hydroelectric dams on the mainstem of the river and 18 in the watershed. Fish ladders have been installed on the lower dams allowing anadromous fish passage to Lewiston Falls (Brown *et al.* 2006). The dams play a considerable role in the poor water quality of the river, causing reduced DO throughout the summer. During the 60s, most of the river had oxygen levels of 0ppm, resulting in massive fish kills. There is still a 14 mile stretch of river that requires aerators to provide dissolved oxygen to the river.

The Merrimack River watershed has over 500 dams, including three in Massachusetts and three in New Hampshire, that essentially make the mainstem into a series of ponds (Dunn 2002, Jackson *et al.* 2005). Flow alteration is considered a problem on the upper mainstem of the river and has resulted in the river not meeting EPA's flow requirements (USACE 2003).

Mining

Mining in Northeast Atlantic watersheds first began prior to the Civil War. Since then, mining has been conducted for granite, peat, roofing slate, iron ore, sulfur, magnetite, manganese,

copper, zinc, mica, and other materials. Currently, exploration for precious metals and basic metals is ongoing, but to a lesser extant than during the 1980s. Recent mining activities were conducted in this region by The Penobscot Nation, Champion Paper Company, Oquossoc Minerals, Boliden Resources, Inc., Black Hawk Mining, and BHP-Utah. There are several abandoned mines in the Northeast Atlantic coast watersheds that have become superfund sites due to excessive pollutants being leached into groundwater, such as Elizabeth Mine, Pike Hill Mine, Calhoun Mines, and others. Common pollutants leaked by mining operations in this area are lead, mercury, arsenic, and selenium (Ayuso *et al.* 2006, Piatak *et al.* 2006). All mines that are not in use are supposed to be decommissioned and cleaned up, but the impacts could persist for years before the rivers return to their pristine state.

Commercial and Recreational Fishing

The primary commercial fisheries along the Northeast Atlantic coast by harvest weight exist for herring (39%), lobster (26%), blue mussel (6%), hatchery-origin sea-run Atlantic salmon (4%), groundfish (4%), quahog (4%), soft clam (3%), sea cucumber (3%), seaweed (3%), crabs (2%), and various other species (6%). Directed harvest of shortnose sturgeon and wild Atlantic salmon is prohibited by the ESA; however, both are taken incidentally in other fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979, Dovel *et al.* 1992, Collins *et al.* 1996). Since 2006, a 30 day recreational fishing season between mid September and mid October for hatchery-origin Atlantic salmon has been permitted on the Penobscot River, the only river with listed Atlantic salmon that allows salmon fishing. On the Penobscot, spring salmon fishing has not taken place since 1999, but may be permitted again in 2008. Poaching is likely another fishing threat, but its impacts to individual population segments is unknown. Entanglement of marine mammals in fishing gear is not uncommon and can lead to mortality or serious injury.

Long Island Sound and the Connecticut River

Natural History. The Long Island Sound watershed includes portions of Connecticut, New York, Massachusetts, New Hampshire, Rhode Island and Vermont. Long Island Sound was designated a national estuary in 1987, due to its significance as an area where freshwater from the Connecticut, Thames, and Housatonic Rivers (90% of the freshwater input) mixes with the Atlantic Ocean. The sound ranges in salinity from 23 parts per thousand (ppt) in the western end to 35ppt on the eastern side. The surface area of Long Island Sound is 1,320 mi^2, draining an area of over 16,000 mi^2. Long Island Sound connects to the Atlantic Ocean on both the eastern and western side, called "The Race" and the East River, respectively. The sound substrate is primarily mud, sand, silt, and clay, with very small areas of exposed bedrock. The sound is home to more 120 species of fish and at least 50 species use the sound as spawning grounds.

The Connecticut River drains a watershed of 11,259 mi^2 and flows approximately 410 miles to Long Island Sound. The river flows from the highlands of New Hampshire and Quebec, and is bordered by the Green and White Mountains. The Connecticut River's bed is composed of glacial deposits and granitic bedrock. The average precipitation is approximately 43 inches per year. At the mouth, the average discharge is 10.2 billion gallons each day, or 15,715 cubic feet per second, which accounts for approximately 70% of the freshwater inflow to Long Island Sound (Jackson *et al.* 2005). The final 56 miles of the river prior to Long Island Sound is a tidal

estuary (Jackson *et al.* 2005). The river and estuary are also important for many fish species, with 64 freshwater and 44 estuarine species having been recorded in the river or estuary, but 20 of the fish are nonnative (Jackson *et al.* 2005).

Human Activities and Their Impacts

Land Use

More than eight million people live in the Long Island Sound watershed. With so many people in the watershed, both point and non-point source pollution is a major concern. Toxic substances often adsorb to the surface of sediments, which means sediments with high surface to volume ratios like sand, silt, and clay, can hold more pollutants than larger substrates. The sound has elevated levels of PCBs, PAHs, nitrogen, lead, mercury, cadmium, cesium, zinc, copper, and arsenic. Organic and metal contaminants in Long Island Sound are above national averages (Turgeon and O'Connor 1991). Lead, copper, and zinc are believed to be deposited via the atmosphere (Cochran *et al.* 1998). Cadmium, chlordane, and lead appear to be decreasing while copper is increasing (Turgeon and O'Connor 1991). Studies on winter flounder showed PAHs and PCBs leading to alteration of DNA in the livers of those fish (Gronlund *et al.* 1991). One of the biggest problems facing the sound is DO depletion (Parker and O'Reilly 1991), resulting in dead zones. The governors of Connecticut and New York have signed agreements to reduce the total nitrogen input to Long Island Sound by 58.5% before 2015 in an effort to get the DO of surface water above 5ppm, of deeper water above 3.5ppm, and no water ever below 2ppm.

Within the Connecticut River watershed the dominant land use is forest (80%), with 11% used for agriculture and the remaining 9% in mixed (other) uses (Jackson *et al.* 2005). Major towns in the Connecticut watershed are Holyoke and Springfield, Massachusetts and Hartford, Connecticut. The human population in the watershed is approximately 179 people per square mile (Jackson *et al.* 2005). Throughout the 20th century, power plants, defense contractors, municipalities, and corporations such as General Electric, Union Carbide, and Pfizer contributed large quantities of pollutants to the river. Still to this day, approximately one billion gallons of raw sewage enters the river as a result of combined sewer overflow from Hartford, Connecticut alone (CRWC 2006). The river has become much cleaner since the CWA was passed, but chromium, copper, nickel, lead, mercury, and zinc, chlordane, DDT, DDE, PCBs, and PAHs are found in quantities above the EPA recommended levels in sediments and fish tissue throughout the watershed (Jackson *et al.* 2005). Acid rain also affects rivers in the northeast, as it reduces the pH of rivers and causes metals to leach from bedrock at a faster rate (USFWS 2007).

Hydromodification Projects

The Connecticut River has 16 hydroelectric dams on the mainstem of the river and as many as 900 are estimated to have been built in the watershed. Fish ladders have been installed at Vernon, Turner Falls, and Holyoke Dams allowing fish passage to areas above Holyoke Dam in Massachusetts since 1981 (USGS 2004). For some species, the ladders are not efficient, so fish passage continues to be compromised. For instance, overall passage efficiency at Turner Falls fish ladder is 17%, and has historically been inefficient at passing shad. Shortnose sturgeon are not able to migrate to spawning habitat above Holyoke Dam, which was recently re-licensed through 2039, so the only spawning shortnose sturgeon in the river are the fish that reside above the dam. The dams also affect the river's water quality, causing reduced DO and elevated water

temperatures throughout the summer.

Mining

Dating back thousands of years, there is evidence of native people mining and extracting natural resources from the headwaters of the Connecticut River. There are many mines along the Connecticut River, which currently degrade the river's water quality, including the country's first chartered copper mine. Towns such as Plymouth, Vermont were famous for mining gold, iron, talc, soapstone, marble, asbestos, and granite (Ewald 2003). Other towns through New Hampshire and Vermont also mined gold, silver, soapstone, talc, granite, slate, and copper (Ewald 2003). In many locations, far downstream of the mines, accumulated heavy metals are in concentrations high enough to threaten aquatic life. In other cases, the mines are abandoned or failing and need to be cleaned. Such is the case with Elizabeth Mine, an old copper mine perched above the Connecticut River that leaches heavy metals into the river. As a result, Elizabeth Mine has been declared a superfund site. There is little to no mining in Long Island Sound and the concept is generally frowned upon in the region, although there has been and continues to be discussions about mining for sand and gravel.

Commercial and Recreational Fishing

There are not many commercial fisheries in the Connecticut River. Shad is the primary commercial fishery here, although shellfish, bluefish, striped bass, and flounder can be caught in the tidal estuary near the mouth. There are many recreationally angled fish, such as shad, striped bass, bluefish, northern pike, largemouth and smallmouth bass, perch, catfish, and other fish.

Long Island Sound fisheries provide an estimated 5.5 million dollars to the Connecticut economy. The primary fisheries target oysters, lobsters, scallops, blue crabs, flounder, striped bass, and bluefish. Recently, due to DO deficiencies, the western portion of Long Island Sound has seen major declines in fish and shellfish populations. Despite these recent declines, the sound houses the largest oyster fishery in the US, which provides 95% of the nation's oysters. At this same time, lobsters have been suffering from an unknown disease and their population has been declining. Simultaneously, menhaden have made a dramatic recovery over the past 10 years, which has resulted in much better fishing for larger predatory fish such as striped bass.

Directed harvest of shortnose sturgeon is prohibited by the ESA. However, shortnose sturgeon are likely taken incidentally in fisheries in the Connecticut River and Long Island Sound. Moser and Ross (1993) found that captures of shortnose sturgeon in commercial shad nets disrupted spawning migrations in the Cape Fear River, North Carolina, and Weber (1996) reported that these incidental captures caused abandonment of spawning migrations in the Ogeechee River, Georgia. Entanglement of marine mammals in fishing gear is not uncommon and can lead to mortality or serious injury.

Hudson River Basin

Natural History. The Hudson River flows approximately 315 miles to the ocean, with a watershed of 13,365 mi^2. The river flows from the Adirondack Mountains, draining most of eastern New York State, to the ocean where the Hudson River canyon continues onto the continental shelf, marking where the original mouth of the Hudson was covered by rising sea

levels after the last ice age. The Hudson River's bed is composed of metamorphosed plutonic rock in the Adirondack Mountains, then transitions to sedimentary rock, such as shale and limestone in the middle portion of the watershed, and the lower portion of the watershed is a mixture of sedimentary, metamorphic, and igneous rocks. The average precipitation is approximately 36 inches per year. At the mouth, the average discharge is 13.5 billion gallons each day, or 20,906 cubic feet per second (Jackson et al. 2005). The Hudson is a freshwater tidal estuary between Troy, NY at river mile 154 to Newburgh Bay at river mile 62, and then it is a tidal brackish estuary for the lower 62 miles to the Atlantic Ocean (Jackson et al. 2005). The river and estuary are home to over 200 fish species, with approximately 70 native freshwater fish species and 95 estuarine species having been recorded (Jackson et al. 2005).

Human Activities and Their Impacts

Land Use

The Hudson River watershed usage is 25% agriculture, 65% forested, 8% urban, and 5% other (Jackson *et al.* 2005). Major towns in the Hudson River watershed are New York City, Albany, Poughkeepsie, and Hudson, New York and Jersey City, New Jersey. The human population in the watershed is approximately 350 people per square mile, but there are no people living in the headwaters and the population density in Manhattan is over 25,907 people per square mile (Jackson *et al.* 2005).

Throughout the 20th century, power plants, municipalities, pulp and paper mills, and corporations such as IBM, General Motors, and General Electric in particular, who the EPA estimates dumped between 209,000 and 1.3 million pounds of PCBs into the river, contributed large quantities of pollutants to the Hudson. The PCB levels in the Hudson River are amongst the highest nationwide. The upper basin is mostly unaffected by humans, with clear, soft water with low nutrients. The middle Hudson is more polluted, with 30 to 50% of the land in this region being used for agriculture and several cities such as Corinth, Glens Falls, Hudson Falls, and Fort Edward contributing industrial waste to the river. The tidal freshwater portion of the Hudson is nutrient rich with exceptionally low gradient. High tide in this stretch causes the river to flow backwards due to the low gradient and this prevents stratification. The brackish tidal estuary portion of the Hudson is nutrient rich with hard water. Two hundred miles of the Hudson River, from Hudson Falls to New York City, were designated as a superfund site due to the amount of pollution. There are still elevated amounts of cadmium, copper, nickel, chromium, lead, mercury, and zinc, DDT, PCBs, and PAHs are found in quantities above the EPA recommended levels in sediments and fish tissue throughout the watershed (Wall *et al.* 1998).

Hydromodification Projects

The mainstem Hudson River has 14 dams and there are dams near the mouths of many tributaries, but the lower 154 miles of tidally influenced river is undammed. Several flood control dams on tributaries such as the Indian and Sacandaga Rivers have drastically altered the flow of the mainstem Hudson River. The Hudson is an important river for anadromous fishes because it is unobstructed for the lower 154 miles, resulting in the healthiest population of ESA-listed endangered shortnose sturgeon in the United States. Prior to the Clean Water Act, the middle stretch of the Hudson and much of the lower reaches had low dissolved oxygen as a result of reduced flow behind the dams, high nutrients, and the collection of waste with high

biological oxygen demand.

Mining

The Hudson River has been periodically important as a source of metals and mined resources. The Adirondack Mountains, in the headwaters, have mined silver, iron, titanium, coal, talc, vanadium, graphite, garnet, and zinc at various times over the past 300 years. McIntyre Mine is an example of a mine that has produced different minerals during different generations. Initially bought as an iron mine, McIntyre sat dormant for 75 years before titanium was discovered there, at which point National Lead purchased it and mined there until 1982 when NL Industries abandoned the mine.

Commercial and Recreational Fishing

The Hudson River commercial fishery historically caught fish, blue crabs, and oysters. Now, the only fish that is caught commercially in the Hudson is American shad. Historically, Atlantic sturgeon, striped bass, American eel, and white perch were productive commercial fisheries. The striped bass fishery closed in 1976 due to PCBs in the river and fish tissue. Atlantic sturgeon were fished until the mid 1990s. Blue crabs are still fished in the estuary all the way to Troy, NY with recent catches over 88,185 pounds per year. There is no commercial fishery for oysters but they used to be taken commercially in the brackish tidal section of the Hudson.

Delaware River Basin

Natural History. The Delaware River flows approximately 329 miles to the ocean, with a watershed of 12,757 mi^2. The river originates in the Catskill Mountains with over half of the river flowing through Pennsylvania and the rest of the watershed occupying parts of New Jersey, New York, and Delaware. The Delaware River's geology is sandstone with shale conglomerate in the upper watershed transitioning to sandstone, shale, and limestone in the middle watershed and igneous and metamorphic rock in the lower watershed. The average precipitation is approximately 43 inches per year. At the mouth, the average discharge is 9.6 billion gallons each day, or 14,903 cubic feet per second, and although it is only the 42nd largest river by discharge, Philadelphia is home to the largest freshwater port in the country (Jackson et al. 2005). The Delaware River estuary begins in Trenton, New Jersey and extends downstream for 144 miles (Jackson et al. 2005). The river and estuary are home to 105 species of fish, with approximately 8 nonnative fish (Jackson et al. 2005).

Human Activities and Their Impacts

Land Use

The Delaware River watershed usage is 24% agriculture, 60% forested, 9% urban, and 7% surface water or other (Jackson *et al.* 2005). Major towns in the Delaware River watershed are Easton, Allentown, Reading, and Philadelphia, Pennsylvania; Trenton and Camden, New Jersey; and Wilmington, Delaware. The human population in the watershed is approximately 555 people per square mile (Jackson *et al.* 2005). The water quality was significantly degraded around Philadelphia by 1799. By the 1960s the average DO in the lower river was approximately 0.2ppm. A survey in the 1970s of organochlorine frequency in rivers ranked the Delaware at Trenton and the Schuylkill, the largest tributary to the Delaware, as the 8th and 1st

worst, respectively in the nation (Jackson *et al.* 2005). While there aren't many point sources of pollution since the Clean Water Act was enacted, historically, power plants, municipalities, pulp and paper mills, and industries such as the Philadelphia Shipyard, Bethlehem Steel, New Jersey Zinc Company, contributed large quantities of pollutants to the Hudson. Approximately 95% of PCBs are introduced to the river through combined sewage overflows from treatment plants. Even 35 years after the Clean Water Act, there are still elevated amounts of copper, chromium, lead, mercury, and zinc, DDT, PCBs, and PAHs are found in quantities above the EPA recommended levels in sediments and fish tissue throughout the watershed. (Wall *et al.* 1998). The heaviest concentrations of chemicals in the river occur in a 14 mile stretch between the Philadelphia naval yard and the Tacony-Palmyra Bridge.

Hydromodification Projects

The Delaware River has 16 dams in the headwaters but the middle and lower river is the longest undammed stretch of river east of the Mississippi. This stretch of free-flowing river is beneficial to anadromous and catadromous species, such as American shad, striped bass, and American eels.

Mining

The Delaware River watershed, particularly the eastern section was home to the majority of the nation's anthracite coal. As a result, many mining towns were established in the watershed to exploit the abundant resources. By 1914, over 181,000 people were employed as miners in the region. Apart from the coal mining, other minerals such as sulfur, talc, mica, aluminum, titanium, and magnesium were mined. Mines were also established for sand and gravel. Eventually minerals from the watershed were used to produce steel.

Commercial and Recreational Fishing

In the Delaware River, commercial fisheries exist for American shad, weakfish, striped bass, Atlantic croaker, Atlantic silversides, bay anchovy, black drum, hogchoker, northern kingfish and American eel. Commercial fishermen use gillnets and trawls as the primary means of capturing fish. Bycatch is a concern for the recovery of endangered shortnose sturgeon, where the highest mortality rates are recorded in gillnet fisheries. Recreational fishermen target weakfish, striped bass, croaker, drum, kingfish, and eel. No data exists on shortnose sturgeon poaching.

Chesapeake Bay Drainages

Natural History. Chesapeake Bay, the largest estuary in the United States, was formed by glacial activity more than 18,000 years ago. The Bay stretches some 200 miles from Havre de Grace, Maryland to Norfolk, Virginia, with more than 11,000 miles of shoreline. At its widest point, Chesapeake Bay is about 35 miles wide (near the Potomac River). Despite its massive size, the Bay is relatively shallow—average depth is only 21 feet—making it susceptible to significant fluctuations in temperature.

The Bay lies totally within the Atlantic Coastal Plain but the watershed includes parts of the Piedmont Province and the Appalachian Province. The tributaries provide a mixture of waters with a broad geochemical range to the Bay with its own mixture of minerals, nutrients and

sediments depending on the geology of the place where the waters originate. In turn, the nature of the Bay itself depends on the characteristics and relative volumes of these contributing waters. While more than 50 tributaries deliver freshwater to Chesapeake Bay, major rivers include the Susquehanna, Potomac, and the James River, which we describe in greater detail below.

Susquehanna River

Rated as the 18th largest river in the United States based on discharge, drainage area, or length, the Susquehanna River flows approximately 448 miles to the ocean, with a watershed of 27,580 mi^2 (Kammerer 1990; Jackson *et al.* 2005). The river flows north to south from New York, through Pennsylvania, and reaches the Chesapeake Bay in Havre de Grace, Maryland. The Susquehanna River's bed is rocky throughout, being described as a mile wide and a foot deep, with distinct pool/riffle formations even near the mouth. The average precipitation is approximately 39 inches per year. At the mouth, the average discharge is 26.3 billion gallons each day, or 40,718 cubic feet per second, and serves as the primary freshwater source of the Chesapeake Bay (Jackson *et al.* 2005). The Susquehanna isn't tidally influenced and doesn't have much estuary habitat (Jackson *et al.* 2005). The river is home to 103 fish species, but 27 of the fish are nonnative (Jackson *et al.* 2005).

Potomac River

The Potomac River is approximately 383 miles long and has a watershed of 14,670 mi^2. The river's headwaters begin in the Allegheny Mountains of West Virginia and the Potomac most famously flows through Washington, D.C., to the western side of the Chesapeake Bay. The substrate of the Potomac and its tributaries is mostly schist, phyllite, and metavolcanic rock. The average precipitation is approximately 39 inches. At the mouth, the average discharge is 7.3 billion gallons each day, or 11,301 cubic feet per second (Jackson *et al.* 2005). The Potomac River estuary begins two miles below the Washington, D.C. Maryland border, just below the Little Falls of the Potomac River. Ninety-five fish species live in the Potomac, but only 65 of those are native to the area (Jackson *et al.* 2005).

James River

The James River is approximately 340 miles long and drains a watershed of 10, 432 mi^2. The James River is one of the longest bodies of water in entirely in one state, beginning in the Allegheny Mountains of western Virginia and flowing across the state to the Chesapeake Bay. The upper James River's geology is primarily schist and siliclastic rock. The middle James River is primarily course grained conglomerates and sandstone. The lower section of the James is almost entirely sedimentary rock. The average precipitation is approximately 40 inches. At the mouth, the average discharge is 6.5 billion gallons each day, or 10,030 cubic feet per second (Blue 1998). The James River estuary begins at the fall-line in Richmond, Virginia. Ninety-five fish species live in the Potomac, but only 65 of those are native to the area (Jackson *et al.* 2005).

Human Activities and Their Impacts

Land Use

The Susquehanna River watershed usage is 20% agriculture, 63% forested, 9% urban, and 7% pasture (Jackson *et al.* 2005). Major towns in the Susquehanna River watershed are Scranton, State College, and Harrisburg, Pennsylvania and Havre de Grace, Maryland. The human

population in the watershed is approximately 145 people per square mile (Jackson *et al.* 2005). The water quality has not been well documented because the river wasn't used as a primary source of drinking water for any major cities. The three main events that had the greatest effect on the river were logging, dam building, and mining. While most of these activities took place in the 1800s, the river is still responding to the disruption they caused (Jackson *et al.* 2005). Sediment transport in the early 1900s was nine times higher than it was 200 years earlier, due to logging and agriculture. Sediment transport and its associated nutrients remain a major concern for the Chesapeake Bay. Coal is abundant through the watershed, amounting to nearly 30 billion tons of coal mined. Coal waste and acid mine drainage damaged much of the river and its tributaries. There was so much coal silt in the Susquehanna at one point that a fleet of over 200 vessels began harvesting the silt from the river's bed. From 1920 to 1950, over 3 million tons of coal were harvested from behind one dam. Later, between 1951 and 1973, over 10 million tons were harvested from behind another dam. Coal is no longer a primary industry in the watershed, but the impacts of the acid mine drainage are still prominent. Another major problem is untreated sewage and industrial waste that is dumped directly into the river. In Binghampton, New York, there are 10 sewer outfalls, 70 in Scranton, Pennsylvania, 65 in Harrisburg, Pennsylvania, and the number of outfalls totals over 400 in the watershed, generally with the number of outfalls being proportional to the size of the city. As a result, the Susquehanna contributes 44% of the nitrogen and 21% of the phosphorous to the Chesapeake Bay. This has led to large algal blooms in the bay and a resulting "dead zone" between Annapolis, Maryland and Newport News, Virginia. In 2005, the Susquehanna was named America's most endangered river by American Rivers, who produce an annual list. Even 35 years after the Clean Water Act, there are still elevated amounts of copper, sulfur, selenium, arsenic, cobalt, chromium, lead, mercury, zinc, and pesticides (Beyer and Day 2004).

The Potomac River watershed usage is 32% agriculture, 58% forested, 5% developed, 4% water, 1% wetland, and 1% barren (Jackson *et al.* 2005). Major towns in the Potomac River watershed are Washington, D.C.; Arlington and Alexandria, Virginia; and Hagerstown, Maryland. The human population in the watershed is approximately 358 people per square mile (Jackson *et al.* 2005). The water quality has significantly improved over the past 50 years. Even 35 years after the Clean Water Act, there are still elevated amounts of cadmium, chromium, copper, lead, dioxin, PCBs, and chlordane, which may have resulted in recent highly publicized reports of male fish producing eggs.

The James River watershed usage is 23% agriculture, 71% forested, and 6% urban (VDCR 2006). Major towns in the James River watershed are Charlottesville, Richmond, Petersburg, and Hampton Roads, Virginia. The human population in the watershed is approximately 2.5 million people, or approximately 240 people per square mile (VDCR 2006). The James River has 21 municipal dischargers permitted and 28 permitted industrial dischargers. There are also 18 EPA Superfund sites along the river, mostly found in the major cities along its corridor. In some cases, industries such as Allied Chemical were fined and forced to clean up large areas of extreme toxicity. Even 35 years after the Clean Water Act, there are still elevated amounts of zinc, copper, cadmium, nickel, chromium, lead, arsenic, dioxin, PCBs, and pesticides.

Hydromodification Projects

There are many dams along the Potomac River and its tributaries, but only three impoundments

are larger than 1.5 square miles. One of the major tributaries, the Anacostia River, is having over 60 dams removed or altered to improve water quality and fish passage.

The Susquehanna River has over 100 dams along the mainstem and the first major dam is located just 10 miles upstream of the mouth. In recent years modern fishways have been installed in some of these dams and migratory fish appear to be responding positively. For instance, between 1928 and 1972, no shad passed Conowingo Dam, 10 miles upstream of the mouth of the Susquehanna River, but since fish began coming back, their abundance has increased from approximately 100 to more than 100,000.

The James River has several large dams along its length. Many dams have been removed or improved to allow fish passage, and in 1999, a ladder was built over Boscher Dam, which had prevented upstream fish runs since 1823. That ladder provided access to 137 additional miles of the James and 168 miles of its tributaries.

Mining

In the Chesapeake Bay watershed, coal mining has likely had the most significant impact on water quality. Mining in this watershed was so extensive that while many mines have been reclaimed and others are currently being reclaimed, at the current level of funding, it will take decades or more to completely reclaim all of the old mines in the watershed. Abandoned coal mines leach sulfuric acid as a result of natural reactions with the chemicals found in coal mines. Many of these abandoned coal mines must be treated with doses of limestone to balance the pH of the water draining from the mines. Much of the Appalachian Mountain chain that was mined for coal is now leaching sulfuric acid into tributaries of the Chesapeake Bay and requires some sort of treatment to improve the water quality of the region.

Commercial and Recreational Fishing

The Chesapeake Bay supports fisheries for American eel, croaker, blue crab, black sea bass, bluefish, oyster, red drum, spot, striped bass, summer flounder, weakfish, menhaden, and white perch (CFEPTAP 2004). Stocks of striped bass got so low in the mid 1980s that a moratorium started in 1985, but they recovered so well that well-regulated harvests are now permitted. Since the mid 1990s, levels of blue crab and menhaden have dropped to the lowest levels in history. Species such as catfish and white perch are year round residents and managed by individual states around the bay. Species like Spanish mackerel, king mackerel, red drum, and summer flounder have ranges that extend beyond the bay and are managed under multiple regional management plans. Some species such as American shad are allowed to be fished by some states (Virginia and Maryland) within the Chesapeake Bay, but not by other states (Delaware and Pennsylvania).

Southeast Atlantic Region

This region covers all the drainages that ultimately drain to the Atlantic Ocean between the states of North Carolina and Florida. This region includes all of South Carolina and parts of Georgia, North Carolina, Florida, and Virginia. The region encompasses three ecoregions—the hot continental division, subtropical division, and savanna division (southern most tip of Florida's panhandle). The hot continental division is characterized by it's winter deciduous forest dominated by tall broadleaf trees, soils rich in humus and moderately leached (Inceptisols,

Ultisols, and Alfisols), and rainfall totals that decrease with distance from the ocean (Bailey 1995).

Most of the Southeast Atlantic Coast Region is contained within the subtropical ecoregion and is characterized by a humid subtropical climate with particularly high humidity during summer months, and warm mild winters. Soils are strongly leached and rich in oxides of iron and aluminum (Bailey 1995). The subtropical ecoregion is forested, largely by second growth forests of longleaf, loblolly and slash pines, with inland areas dominated by deciduous trees. Rainfall is moderate to heavy with annual averages of about 40 inches in the north, decreasing slightly in the central portion of the region, and increasing to 64 inches in southern Florida. The savanna ecoregion has a tropical wet-dry climate, controlled by moist warm topical air masses and supports flora and fauna that is adapted to fluctuating water levels (Bailey 1995).

In the sections that follow we describe several basins and estuaries to characterize the general ecology and natural history of the area, and past and current human activities and their impacts on the area. The region contains more than 22 river systems that generally flow in a southeasterly direction to the Atlantic Coast. The diverse geology and climate ensures variability in biological productivity and hydrology. Major basins include the Albemarle-Pamlico Watershed and its tributaries, the Cape Fear River, Winyah Bay and the Santee-Cooper Systems, the Savannah, Ogeechee, and the St. Johns River, to name a few. The more northerly river, the Roanoke which is part of the Albemarle-Pamlico Watershed, is cooler and has a higher gradient and a streambed largely characterized by cobble, gravel and bedrock.

The southern rivers are characterized by larger portions of low gradient reaches, and streambeds that are composed of greater amounts of sand and fine sediments—are often high in suspended solids, and have neutral to slightly acidic waters with high concentrations of dissolved organic carbon. Rivers emanating entirely within the Coastal Plain are acidic, low alkalinity, blackwater systems with dissolved organic carbon concentrations often up to 50 mg/L (Smock *et al.* 2005). We described several river basins in detail to provide additional context for evaluating the influence of the environmental baseline on listed species under NMFS' jurisdiction and the health of the environment.

Albemarle-Pamlico Sound Complex

Natural History. The Albemarle-Pamlico Sound Estuarine Complex, the largest lagoonal estuarine system in the United States, includes seven sounds including Currituck Sound, Albemarle Sound, Pamlico Sound and others (EPA 2006). The Estuarine Complex is separated from the Atlantic Ocean by the Outer Banks, a long barrier peninsula, and is characterized by shallow waters, wind-driven tides that result in variable patterns of water circulation and salinity. Estuarine habitats include salt marshes, hardwood swamp forests, and bald cypress swamps.

The Albemarle-Pamlico watershed encompasses four physiographic regions—the Valley and Ridge, Blue Ridge, Piedmont and Costal Plain Provinces. The geology of the basin strongly influences the water quality and quantity within the basin. The headwaters of the basin tributaries are generally steep and surface water flowing downstream has less opportunity to pick up dissolved minerals. However, as the surface water flows reaches the Piedmont and Coastal

Plain, water velocity slows due to the low gradient and streams generally pick up two to three times the mineral content of surface waters in the mountains (Spruill *et al.* 1998). At the same time, much of the upper watershed is composed of fractured rock overlain by unconsolidated and partially consolidated sands. As a result, of the basin's geology, as a general matter more than half of the water flowing in streams discharging to the Albemarle-Pamilico Estuarine Complex comes from ground water.

Primary freshwater inputs to the Estuary Complex include the Pasquotank, Chowan and Roanoke Rivers that flow into Albemarle Sound, and the Tar-Pamlico and Neuse Rivers that flow into Pamlico Sound. The Roanoke River is approximately 410 miles long and drains a watershed of 9,580 mi^2. The Roanoke River begins in the mountains of western Virginia and flows across the North Carolina border before entering the Albemarle Sound. The upper Roanoke River's geology is primarily a high gradient boulder-rubble bedrock system. The middle Roanoke River is primarily course sand and gravel. The lower section of the Roanoke is almost entirely organic-rich mud. The average precipitation is approximately 43 inches. At the mouth, the average discharge is 5.3 billion gallons each day, or 8,193 cubic feet per second (Smock *et al.* 2005). The Roanoke River is home to 119 fish species, and only seven of those are not native to the area (Smock *et al.* 2005). The Roanoke is also home to nine endangered fish species, two amphibians, and seven mussels, including several important anadromous fish species.

The Neuse River is 248 miles long and has a watershed of 6,235 mi^2 (Smock *et al.* 2005). The Neuse River watershed is also located entirely within the state of North Carolina, flowing through the same habitat as the Cape Fear River, but ultimately entering Pamlico Sound. The river originates in weathered crystalline rocks of the piedmont and crosses sandstone, shale, and limestone before entering Pamlico Sound (Turekian *et al.* 1967). The average precipitation is approximately 48 inches. At the mouth, the average discharge is 3.4 billion gallons each day, or 5,297 cubic feet per second (USGS 2005).

Human Activities and Their Impacts

Land Use

Land use in the Roanoke River is dominated by forest (68%) and the basin contains some of the largest intact, least disturbed bottomland forest floodplains along the eastern coast. Only 3% of the basin qualifies as urban land uses, and 25% is used for agriculture (Smock *et al.* 2005). The only major town in the Roanoke watershed is Roanoke, Virginia. The population in the watershed is approximately 80 people per square mile (Smock *et al.* 2005). In contrast, the Neuse River watershed is described as 35% agriculture, 34% forested, 20% wetlands, and 5% urban, and 6% other, with a basin wide density of approximately 186 people per square mile (Smock *et al.* 2005). While the population increased in the Albemarle-Pamlico Complex more than 70% during the last 40 years, the rate of growth is relatively low for many coastal counties in the Southeast (EPA 2006). Much of the estuarine complex is protected by large amounts of state and federally protected lands, which may reduce development pressures.

Throughout the 20th century, mining, agriculture, paper and pulp mills, and municipalities contributed large quantities of pollutants to the Roanoke River and the Albemarle-Pamlico Estuarine Complex. Even so, today the Albemarle-Pamlico Estuarine Complex is rated in good

to fair condition in the National Estuary Program Coastal Condition Report despite that over the past 40-year period data indicate some noticeable changes in the estuary, including increased dissolved oxygen levels, increased pH, decreased levels of suspended solids, and increased chlorophyll *a* levels (EPA 2006).

Coal is mined from the mountainous headwaters of the Roanoke River in southwestern Virginia. Mining through the piedmont and coastal areas of North Carolina was conducted for limestone, lead, zinc, titanium, apatite, phosphate, crushed stone, sand, and fossils. Many active mines in these watersheds are still in operation today. These mines are blamed for increased erosion, reduced pH, and leached heavy metals.

Agricultural activities are major source of nutrients to the estuary and a contributor to the harmful algal blooms (HABs) in summer, although according to McMahon and Woodside 1997 (cited in EPA 2006) nearly one-third of the total nitrogen inputs and one-fourth of the total phosphorus input to the estuary are from atmospheric sources. Primary agricultural activities within the watershed include corn, soybean, cotton, peanut, tobacco, grain, potato, and the production of chicken, hog, turkey, and cattle.

In general, the Roanoke River is much cleaner since the passage of the CWA, although mercury, arsenic, cadmium, chromium, copper, lead, nickel, zinc, and PCBs are still considered high (NCDENR 2000). Fish tissues sampled within the estuary also showed elevated concentrations of total PAHs and total PCBs—10% of the sampled stations exceeded risk-based EPA Advisory Guidance values (EPA 2006). Water quality studies in the mid-1990s showed the Neuse Basin contained the highest nitrogen and phosphorus yields, while the Chowan Basin had the lowest yields (Spruill *et al.* 1998).

The Neuse River entered the national spotlight during the early 1990s due to massive and frequent fish kills within the basin. Over one billion American shad have died in the Neuse River since 1991. The problem is persistent but the cause of the kills differs among events; in 2004 more than 700,000 estuarine fish died and more than 5,000 fresh fish died within the basin. Freshwater species most commonly identified during investigations included sunfishes, shad, and carp, while estuarine species most commonly reported included menhaden, perch, and croaker. Atlantic menhaden have historically been involved in a majority of estuarine kill events and have exhibited stress and disease in conjunction with fish kills. Fish kill events may often have different causative agents, and in many cases the precise cause is not clear, but high levels of nutrients, HABs, toxic spills, outbreaks of a marine organism, *Pfiesteria pescicida*, low DO concentrations and sudden wind changes that mix hypoxic waters, are some of contributing factors or causes to the basins persistent fish kills (NCDWQ 2004).

Both the Roanoke River and the Neuse Rivers are fragmented by dams. The reservoirs are used for flood control and recreation, but the amount of agricultural and urban runoff that collects behind the dams has caused sanitation problems in the recent past. Three dams were removed recently in an effort to improve environmental conditions and fish passage. Widespread stream modification and bank erosion were rated high within the greater watershed relative to other sites in the Nation (Spruill *et al.* 1998).

Commercial and Recreational Fishing

The Albemarle and Pamlico Sounds and associated rivers support a dockside commercial fishery valued at over $54 million annually. The commercial harvest includes blue crabs, southern flounder, striped bass, striped mullet, white perch, croaker, and spot, among others. Roughly 100 species are fished commercially or recreationally in the region. The Neuse River supports many of the same species as the Roanoke River.

Commercial and recreational fisheries exist for oyster, crab, clam, American shad, American eel, shrimp, and many other species. Shellfish can be collected by dredging, which has adverse effects to benthic organisms, including shortnose sturgeon that use estuarine areas for feeding. Commercial fisheries along the South Carolina coast use channel nets, fyke nets, gillnets, seines, and trawls. All of those methods must use some sort of turtle excluder device, but could still accidentally capture a shortnose sturgeon.

Major Southeast Coastal Plains Basins

Natural History. More than five major river basins flow through the Coastal Plains of the Southeast and directly enter the Atlantic Ocean including the Cape Fear, Great Pee-Dee, Altamaha, and the St. Johns Rivers. Rainfall is abundant in the region and temperatures are generally warm throughout the year. Northern rivers originate in the Blue Ridge Mountains or the Piedmont Plateau, but all the rivers described in this section have sizeable reaches of slack water as they flow through the flat Coastal Plain. Two rivers, The Satilla River in Georgia and the St. Johns River in Florida, are located entirely within the Coastal Plain. The highest elevation of the St. Johns River is 26 feet above sea level, so the change in elevation is essentially one inch every mile, making it one of the most gradually flowing rivers in the country.

Smock *et al.* (2005) describe the mountains and plateau as areas of heavily dissected and primarily highly metamorphosed rock of Paleozoic age, with occasional areas of igneous and sedimentary rock. Underlying rock is varied with bands of limestone, dolomite, shale, sandstone, cherts, and marble, with a number of springs and caves scattered throughout the area. Where the Piedmont Plateau dips the sedimentary deposits of the coastal plain is termed the fall line. Here, steep changes in elevation result in rapids or falls before the rivers level off in their Coastal Plain reaches. In the Coastal Plain reaches of the areas rivers soils are acidic with a low cation exchange capacity and a sandy or loamy surface horizon, and a loamy or clay subsurface. The acidic characteristics, slow flowing water with poor flushing and high organic and mineral inputs gives these waters their characteristic “blackwater” (or “brownwater” for those that originate in the Piemont Plateau) appearance. The Satilla River is a blackwater river that has a naturally low pH (between 4 and 6) and white sandbars--due to the low pH it also has naturally lower productivity than other rivers that originate within the mountains or the Plateau.

Table 21. Rivers of the Southeast United States (data from NCDENR 1999 and Smock *et al.* 2005).

Watershed	Length (mi.)	Basin Size (mi^2)	Physiographic Provinces*	Mean Annual Precipitation (in.)	Mean Discharge (cfs).	No. Fish Species	No. Endangered Species
Cape Fear River	320	9,324	PP, CP	47	7,663	95	8 fish, 1 mammal, 15 mussels
Great Pee Dee River	430	10,641	BR, PP, CP	44	13,102	>100	6 fish, 1 reptile
Santee-Cooper River	440	15,251	BR, PP, CP	50	15,327	>100	5 fish, 2 reptiles
Savannah River	300	10,585	BR, PP, CP	45	11,265	>100	7 fish, 4 amphibians, 2 reptiles, 8 mussels, 3 crayfish
Ogeechee River	250	5,212	PP, CP	44	4,061	>80	6 fish, 2 amphibians, 2 reptiles, 1 mussel
Altamaha River	140 (>400)	14,517	PP, CP	51	13,879	93	1 mammal, 12 fish, 2 amphibians, 2 reptiles, 7 mussels, 1 crayfish
Satilla River	200	3,530	CP	50	2,295	52	2 fish, 1 amphibian, 2 reptiles, 1 mussel
St. Johns River	311	8,702	CP	52	7,840	>150	1 mammal, 4 fish, 2 reptiles, 2 birds

* Physiographic Provinces: BR = Blue Ridge, PP = Piedmont Plateau, CP = Coastal Plain

Human Activities and Their Impacts

Land Use

Across this region, land use is dominated by agriculture and industry, and to a lesser extent timber and paper production, although more than half of most basins remain forested. Basin population density is highly variable throughout the region with the greatest density in the St. Johns River watershed with about 200 people per square mile of catchment, most of whom are located near Jacksonville, Florida. In contrast, there are only 29 people per square mile in the Saltilla River watershed in Georgia (Smock *et al.* 2005).

The largest population centers in the region include Miami and Jacksonville, Florida, and Savannah, Georgia. Major towns include Greensboro, Chapel Hill, Fayetteville, South Carolina, and Wilmington, North Carolina in the Cape Fear River watershed; Winston-Salem, North Carolina and Georgetown, Florence, and Sumter, South Carolina in the Great Pee-Dee River Watershed; Charlotte, Hickory, and Gastonia, North Carolina and Greenville and Columbia, South Carolina in the Santee-Cooper River watershed; Savannah and Augusta, Georgia, in the

Savannah River watershed; Louisville, Statesboro, and Savannah, Georgia, in the Ogeechee River watershed; Athens, and Atlanta, Georgia, in the Altamaha River watershed; and Jacksonville, Florida in the St. Johns River watershed.

Several of the rivers in the region have elevated levels of metals including mercury, fecal coliform, bacteria, ammonia, turbidity, and low DO. These impairments are caused by municipal sewage overflows, mining, and non-point source pollution, waterfowl, urban runoff, marinas, agriculture, and industries including textile manufacturing, power plant operations, paper mills and chemical plants (Harned and Meyer 1983; Berndt *et al.* 1998; NCDENR 1998; Smock *et al.* 2005).

Several watersheds exhibit high nitrogen loads including the Cape Fear River, Winyah Bay, Charleston Harbor, St. Helena Sound, Savannah River, Ossabaw Sound, Altamaha River, and St. Mary's River and Cumberland Sound (Bricker *et al.* 2007). Nitrate concentrations (as nitrogen) tend to be higher in stream draining basins with agricultural and mixed land uses (Berndt *et al.* 1998). Based on studies in Georgia, however, nitrate loads did not vary with growing season of crops (periods of heaviest fertilizer application), but were influenced by high streamflow, which could be related to downstream transport by subsurface flows (Berndt *et al.* 1998).

Table 22. Land Uses and Population Density in Several Southeast Atlantic Basins (data from Smock *et al.* 2005)

Watershed	Land Use Categories (Percent)				Density (people/mi.^{2})
	Agriculture	Forested	Urban	Other	
Cape Fear River	24	56	9	11	80
The Great Pee-Dee	28	58	8	6	127
Santee-Cooper River	26	64	6	4	168
Savannah River	22	65	4	9	91
Ogeechee River	18	54	1	17 (wetlands)	78
Altamaha River	--	64	3	7	73
Satilla River	26	72	1	1	29
St. Johns River	25	45	6	24 (wetlands & water)	202

Sediment is the most serious pollutant in the Yadkin (Pee-Dee) River and has historically been blamed on agricultural runoff. In the mid 1990s, farmers in the region began using soil conservation techniques that have reduced sediment inputs by 77%. Unfortunately, the reduction in sediment inputs from farms did not translate to a reduction in sediment in the river, as during this period there was a 25% reduction in agricultural land and a 38% increase in urban development.

Mining

Mining occurs throughout the region. South Carolina is ranked 25th in the states in terms of mineral value and 13th among the eastern 26 states, and produces 1% of the total nonfuel mineral production value in the United States. There are currently 13 minerals being extracted from 485 active mines in South Carolina alone. Portland and masonry cement and crushed stone were the State's leading nonfuel minerals in 2004 (NMA 2007). In contrast, Georgia accounts for 4%, Florida accounts for 5%, and North Carolina accounts for 1.76% of the total nonfuel mineral production value in the United States. North Carolina's leading nonfuel minerals in 2004 were crushed stone, phosphate rock, and construction sand and gravel. Georgia produces 24% of the clay in the nation; other leading nonfuel minerals include crushed stone and Portland cement. Florida is the top phosphate rock mining state in the United States and produces about six times more than any other state in the nation. Peat and zirconium concentrates are also produced in Florida.

The first gold mine discovered and operated in the United States is outside Charlotte, North Carolina in the Pee Dee watershed. Mines through Georgia are also major producers of barite and crude mica, iron oxide, and feldspar. There is a proposed titanium mine near the mouth of the Satilla River. Unfortunately, mines release some toxic materials and negatively impact fish, as fish living around dredge tailings have elevated levels of mercury and selenium.

Hydromodification Projects

Several of the rivers within the area have been modified by dams and impoundments. In contrast to rivers along the Pacific Coast, we found considerable less information on other types of hydromodification projects in this area, such as levees and channelization projects. There are three locks and dams along the mainstem Cape Fear River and a large impoundment on the Haw River. The lower river and its tributaries are relatively undisturbed. The lower reach is naturally a blackwater river with naturally low dissolved oxygen, which is compounded by the reduced flow and stratification caused by upstream reservoirs and dams. The Yadkin (Pee Dee) River is heavily utilized for hydroelectric power. There are many dams on Santee-Cooper River System. The Santee River Dam forms Lake Marion and diverts the Santee River to the Cooper River, where another dam, St. Stephen Dam, regulates the outflow of the Santee River. Lake Moultrie is formed by both St. Stephen Dam and Pinopolis Dam, which regulates the flow of the Cooper River to the ocean. Below the fall line, the Savannah River is free-flowing with a meandering course, but above the fall line, there are three large dams that turn the piedmont section of the river into a 100-mile long stretch of reservoir. Although the Altamaha River is undammed, hydropower dams are located in its tributaries the Oconee and Ocmulgee Rivers above the fall lines. There are no dams, however, along the entire mainstem Satilla River. There are no major dams on the mainstem St. Johns River either, but one of the largest tributaries has a dam on it. The St. Johns River's flow is altered, however, by water diversions for drinking water and agriculture.

Commercial and Recreational Fishing

The region is home to many commercial fisheries targeting species like shrimp, blue crab, clams, American and hickory shad, oysters, whelks, scallops, channel catfish, flathead catfish, snapper, and grouper. Shortnose sturgeon can be caught in gillnets, but gillnets and purse seines account for less than 2% of the annual bycatch. Shrimpers are responsible for 50% of all bycatch in

Georgia waters and often interact with sea turtles. There are approximately 1.15 million recreational anglers in Georgia.

VII. Effects of the Proposed Action

In this section of the Opinion, we assess the probable direct and indirect effects of authorizing the proposed action on Atlantic sturgeon in the action area. We also summarize the results of studies that have examined the direct and indirect effects of each sampling procedure on these fish. We rely on these summaries of the literature to determine how individual Atlantic sturgeon are likely to respond upon being exposed to a particular sampling procedure. Based on this body of information, we then assess the risks the activities contained in the proposed permit pose first to particular Atlantic sturgeon populations, then to the DPSs as they are listed.

A. Potential Stressors

The specific stressors associated with the proposed permits are capture; handling; PIT, PSAT, and T-bar/Floy tagging; laparoscopy and boroscopy; gastric lavage; blood sampling; genetic tissue sampling; gonad biopsy; gill biopsy; fin ray sectioning; acoustic transmitter implantation and external acoustic transmitter attachment; anesthetization; hydroacoustic equipment; and early life stage (ELS) sampling. Several stressors could cause unintentional/incidental mortality. The following sections provide specific details of the stressors associated with each procedure and summarize the available data on the responses of individuals that have been exposed to the procedures.

B. Exposure Analysis

Atlantic sturgeon originating from different rivers are known to co-occur in the marine environment and use multiple river systems for life functions, such as foraging. Atlantic sturgeon make extensive migrations, therefore, the geographic river or coastal area they are captured in is not necessarily their river of origin or DPS of origin. They travel through the coastal marine and estuarine environment to enter and use spawning rivers to spawn and also use non-spawning rivers for foraging and other unknown reasons. Only early life stages (ELS), young of the year (YOY), or spawning adults captured in a given river can definitively be identified as originating from the river in which they were captured. Because of their migratory nature, adult, sub-adult, and older/larger juvenile Atlantic sturgeon from all five DPSs have the potential to be located anywhere in their full marine range, estuary, or river along the east coast (see Erikson *et al.* 2011, NMFS observer database, USFWS tagging database). This presents a problem for directed research projects capturing Atlantic sturgeon when examining exposure and take allocation per DPS. Unless the captured Atlantic sturgeon is a YOY, age 1 or 2 juvenile, or a spawning adult, there is no way of knowing which DPS the fish is from without later lengthy genetic analysis. This makes take per DPS difficult to estimate.

Take Allocation Process Based on Genetic Mixed Stock Analyses

Genetic analyses give the greatest clue as to each captured Atlantic sturgeon's river of origin, but genetic analyses and data are sparse in every geographic area and zone (riverine, estuarine,

marine/coastal) in which ATS could possibly be captured during directed research. In August 2011, the NMFS Northeast Regional Office held a sturgeon workshop in Alexandria, Virginia to examine all available scientific information regarding Atlantic sturgeon migration and corresponding available genetic analyses. As a result of this workshop and an examination of the scientific literature, NMFS determined that the best available scientific information yielding river-of-origin-results stemming from genetic mixed stock analyses (MSA) are from Grunwald *et al*. 2008, Grunwald *et al.* 2009, King *et al*. 2001, Waldman *et al.* 1996, Wirgin *et al*. 2000, and two workshop presentations entitled Mixed Stock Analysis (MSA) of Atlantic Sturgeon from Coastal Locales and a Non-Spawning River by Wirgin and King (2011) and Conservation Genetics and Genomics of the Acipenseridae: Population Genetics, Phylogeography, and Transcriptomics by King (2011). These presentations focused on Wirgin and King's genetic research that has not yet been published at the time of this Biological Opinion. In addition, NMFS Protected Resources staff conducted conference calls with Wirgin, King, and other researchers to discuss and obtain results of recent genetic data not yet published or presented. The information collected from these sources is presented below in Table 23.

Table 23. Available MSA information.

Source	Atlantic sturgeon Collection Location for MSA	DPS	% of DPS in Collection Location (MSA)
Wirgin and King 2011	Long Island Sound	Gulf of Maine	0-9
		New York Bight	74-84
		Chesapeake Bay	2-12
		Carolina	0-5.5
		South Atlantic	5-15
Dunton *et al*. 2011	New York Bight	Gulf of Maine	0
		New York Bight	73
		Chesapeake Bay	5
		Carolina	14
		South Atlantic	8
Wirgin and King 2011	Bay of Fundy (Canada)	St. John (Canada)	58-68
		Gulf of Maine	31-41
		New York Bight	0-6
		Chesapeake Bay	0
		Carolina	0
		South Atlantic	0

Source	Atlantic sturgeon Collection Location for MSA	DPS	% of DPS in Collection Location (MSA)
Wirgin and King 2011	Connecticut River	Gulf of Maine	6-16
	(lower 50k of the river)	New York Bight	71-81
		Chesapeake Bay	3-13
		Carolina	less than 1
		South Atlantic	0-6
Wirgin and King 2011	Delaware Coast	Gulf of Maine	2-12
		New York Bight	53-63
		Chesapeake Bay	13-23
		Carolina	0
		South Atlantic	12-22
Wirgin and King 2011	North Carolina Coast	Gulf of Maine	0-6
	(winter survey)	New York Bight	12-22
		Chesapeake Bay	47-57
		Carolina	less than 1
		South Atlantic	25-35
Wirgin and King 2011	Observers' Program	Gulf of Maine	3-13
	North Carolina to Maine/coastal	New York Bight	41-51
		Chesapeake Bay	11-21
		Carolina	0
		South Atlantic	24-34
Bartron *et al*. 2007	Chesapeake Bay	Gulf of Maine	2.60
		New York Bight	38.80
		Chesapeake Bay	45.50
		Carolina	1.30
		South Atlantic	10.30
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	Gulf of Maine	7
		New York Bight	93
		Chesapeake Bay	0

Source	Atlantic sturgeon Collection Location for MSA	DPS	% of DPS in Collection Location (MSA)
		Carolina	0
		South Atlantic	0
Doug Peterson, University of Georgia, 2011 pers. comm.	St Marys River	Gulf of Maine	0
	Note: small sample size of 9	New York Bight	0
		Chesapeake Bay	6-17
		Carolina	0
		South Atlantic	84-94

Since genetic analyses are not available for all areas where researchers may capture Atlantic sturgeon, it is difficult to allocate take per DPS. We used the available MSAs from the literature (Table 23), conference presentations, and personal communication from leading researchers to figure take per DPS. The process of applying each available MSA to each proposed permit in this Biological Opinion was conducted as follows.

First, if a researcher was conducting his/her sampling in areas where a MSA has been done, we applied that MSA to figure the percentage of DPS contribution in the collection location and corresponding take numbers depending on proposed take for that given permit. If a researcher was conducing his/her sampling in an area where a MSA had not been done, we looked to other MSAs as models. In order to decide which model to apply, we examined whether the researcher was sampling in a confirmed spawning river, a non-spawning river, or a coastal area. We also looked to the model with closest proximity to the sampling area. This gave us a relative idea of which MSA to use as a model in the absence of genetic analyses.

Second, we looked to see if the researcher was capturing early life stages (ELS), juveniles, sub-adults, or adults. ELS were assigned to the geographic DPS in which they were collected, since this would be their natal river. Smaller juveniles that would be considered year class 1 or 2 by each researcher were also assigned to the geographic DPS in which they were collected, since it is believed that age-1 and age-2 juveniles are restricted to their natal rivers (Dovel and Berggren 1983, Bain *et al.* 1999). Larger juveniles and sub-adults were treated as adults for the purposes of applying MSA and it was assumed that these life stages could migrate extensively.

Third, in using the MSA data to mathematically figure allocations per DPS for each research project, we took the mean of the confidence interval of the stock contribution percentages as depicted in Table 23 order to yield definitive take numbers for authorization which matched up with the actual requested take numbers.

We acknowledge that there is most likely a temporal component to assigning take allocations based upon timing of research during the year, and also the timing of when the Atlantic sturgeon

were captured for the genetic analyses we rely upon. At this point, we do not have enough information to incorporate a temporal component into how we do our take allocations for Atlantic sturgeon. Researchers we have had personal communication with, such as Dewayne Fox and his students (Delaware State University) and others, acknowledge this temporal component and we await forthcoming data and information in the future.

It is important to note that all of these proposed permits would require researchers to submit genetic samples from their captures. It is expected that these genetic samples will be analyzed and would yield more MSA information for a wider range of sampling locations. Therefore, we expect that, in the future, our exposure analysis could change as we incorporate more genetic information produced from a wider array of capture/sampling locations.

DPS Take Allocation Calculations Per Permit

Permit 16526

Gail Wipplehauser's (permit 16526) research would occur in the Kennebec, Penobscot, Saco, Merrimack, and small coastal rivers of Maine, Massachusetts, and New Hampshire (Table 24). She proposes to capture 930 Adult/sub-adult, 45 juvenile (*i.e.* age-1 and age-2 juveniles), and 200 early life stages (ELS) per year for all five years of the permit. Of those captures, up to two juveniles and/or one adult Atlantic sturgeon could suffer harmful injury or perish during the course of the study.

Table 24: Proposed annual take of Atlantic sturgeon for Permit 16526 as requested by PR1.

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Geographic Location (Gulf of Maine DPS)
Atlantic Sturgeon	Adult/sub-adult	75	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Boroscope; Anesthetize[1]; Internal sonic tag	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Lavage	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Penobscot River

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Geographic Location (Gulf of Maine DPS)
Atlantic Sturgeon	Juvenile	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample;	Penobscot River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	D-Net	Directed Mortality	Penobscot River
Atlantic Sturgeon	Adult/sub-adult	225	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Internal sonic	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope Anesthetize[1]; Lavage	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Kennebec River
Atlantic Sturgeon	Juvenile	10	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample;	Kennebec River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	100	D-Net	Directed Mortality	Kennebec River
Atlantic Sturgeon	Adult/sub-adult	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Internal sonic	Saco River
Atlantic Sturgeon	Adult/sub-adult	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Saco River
Atlantic Sturgeon	Adult/sub-adult	70	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Boroscope; Blood sample	Saco River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Lavage	Saco River

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Geographic Location (Gulf of Maine DPS)
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Saco River
Atlantic Sturgeon	Juvenile	10	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample;	Saco River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	D-Net	Directed Mortality	Saco River
Atlantic Sturgeon	Adult/sub-adult	100	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic sample; Boroscope;	Small Coastal Rivers of ME
Atlantic Sturgeon	Adult/sub-adult	35	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Internal sonic	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Blood sample	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize; [1] Lavage	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Merrimack River
Atlantic Sturgeon	Juvenile	15	Gill Net, Trawl, Beach Seine	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; External sonic tag	Merrimack River
Atlantic Sturgeon	Adult/sub-adult	15	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1] Internal sonic	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Apical spine sample	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	25	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Lavage	Small Coastal Rivers of MA and NH

Species	Life Stage	Proposed Annual Take	Collect Method	Proposed Take Activities	Geographic Location (Gulf of Maine DPS)
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Boroscope; Blood	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Boroscope; Anesthetize[1]; Fin ray clip	Small Coastal Rivers of MA and NH
Atlantic Sturgeon	Adult/sub-adult	2 Juveniles 1 Adult[2]	Any Method Authorized	Incidental Mortality or Harmful Injury	Any River or Coastal Area in GOM

1. Anesthesia performed using MS-222 or electronarcosis
2. Mortality of 1 Atlantic sturgeon adult over the life of the permit.

There is no MSA data available for the river to be targeted in the study to be conducted under permit 16526. Therefore, we will apply the MSA done (Wirgin and King 2011) for other similar areas as a model to obtain take allocations per DPS for Adults/sub-adults targeted permit locations. We assumed that juveniles (years 1 and 2) and ELS are Gulf of Maine DPS fish and allocated take accordingly for those younger life stages. The Kennebec River is the only confirmed spawning river in the proposed research area. Given the lack of data specific to the Kennebec River, we determined that using data from the Hudson River as a model (next closest confirmed spawning river with MSA analysis) represented the best available information for the Kennebec. For all other non-spawning rivers targeted in this permit, there is no independent genetic analysis to examine, therefore, we reversed the percentages from the Bay of Fundy samples (Wirgin and King 2011). This decision was made based on findings that while not all fish in a particular area originated from that particular DPS, a high percentage of them do stay within close geographic proximity to their DPS of origin. Applying the mean of stock contribution percentages of the Hudson River (Fox and King 2011, supplemental data to Wirgin and King 2011) and reversed Bay of Fundy (Wirgin and King 2011) MSAs to permit 16526's proposed annual take yields the following (Table 25) take allocations per DPS.

Table 25. Takes per DPS for permit 16526 using Hudson River and Bay of Fundy MSAs as models.

Source	Atlantic sturgeon Genetic Sample Collection Location for MSA	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16526 Takes per DPS per year
Wirgin and King 2011	Bay of Fundy* (reversed)	All rivers in permit but Kennebec (non-spawning rivers)	St. John/ Canada+	36	221+ Adult/sub-adult
			Gulf of Maine	63	387 Adult/sub-adult 35 small juvenile 100 ELS
			New York Bight	3	18 Adult/sub-adult
			Chesapeake Bay	0	0
			Carolina	0	0
			South Atlantic	0	0
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	Kennebec River	St. John/ Canada+	7	22+ Adult/sub-adult
			Gulf of Maine	93	293 Adult/sub-adult 10 small juvenile 100 ELS
			New York Bight	0	0

Source	Atlantic sturgeon Genetic Sample Collection Location for MSA	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16526 Takes per DPS per year
			Chesapeake Bay	0	0
			Carolina	0	0
			South Atlantic	0	0

* The above genetic percentages add up to more than 100%. This is caused by using ranges for each of the individual DPSs and each of the individual river populations within each of the DPSs. These percentages add up to 102%, therefore, that percentage was applied when doing ratios. Numbers were rounded up or down based on standard rounding methods.
+ Canadian fish are not included in our total authorized take numbers for each DPS.

Permit 16323

Tom Savoy's (permit 16323) research would occur in Connecticut state marine waters, Long Island Sound, and the Connecticut, Thames, and Housatonic Rivers. He proposes to capture 200 Adult/sub-adult life stages per year for all five years of the permit.

Table 26: Proposed annual take of Atlantic sturgeon for Permit 16323

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (New York Bight DPS)
Atlantic Sturgeon	Adult/sub-adult	125	Gill Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Connecticut state marine waters and Long Island Sound; Connecticut, Thames, and Housatonic Rivers
Atlantic Sturgeon	Adult/sub-adult	75	Gill Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal sonic tag	Connecticut state marine waters and Long Island Sound; Connecticut, Thames, and Housatonic Rivers

There is MSA data available for Long Island Sound and the Connecticut River (Wirgin and King 2011) (Table 23), therefore, we will apply the MSA done (Wirgin and King 2011) for this area to Tom Savoy's proposed research to obtain take allocations per DPS. Savoy states that he will be applying effort in the Sound and in the Rivers in approximately a 50/50 fashion. Therefore, we divided the anticipated take of Atlantic sturgeon in half and applied the range of the confidence interval of stock contribution percentages of Long Island Sound and Connecticut River data to Savoy's proposed annual take to yield the following (Table 27) take allocations per DPS.

Table 27. Takes per DPS for permit 16323 using Connecticut River and Long Island Sound MSAs.

Source	Atlantic sturgeon Genetic Sample Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16323 Takes per DPS per year
Wirgin and King 2011	Long Island Sound*	Connecticut State marine waters	Gulf of Maine	4.5	4 adult/sub-adult
Presentation			New York Bight	79	77 adult/sub-adult
			Chesapeake Bay	7	7 adult/sub-adult
			Carolina	2.75	3 adult/sub-adult
			South Atlantic	10	10 adult/sub-adult
Wirgin and King 2011	Connecticut River*	Connecticut, Thames, Housatonic Rivers	Gulf of Maine	11	11 adult/sub-adult
Presentation			New York Bight	76	76 adult/sub-adult
			Chesapeake Bay	8	8 adult/sub-adult
			Carolina	less than 1	1 adult/sub-adult
			South Atlantic	3	3 adult/sub-adult

* The above genetic percentages add up to more than 100%. This is caused by using ranges for each of the individual DPSs and each of the individual river populations within each of the DPSs. Wirgin and King 2011 %'s for Long Island Sound do not add up to 100%. These percentages add up to 103.25, therefore, that percentage was applied when doing ratios. The Connecticut River %'s do not add up to 100%. These percentages add up to 99%, therefore, that percentage was applied when doing ratios. Numbers were rounded up or down based on standard rounding methods.

Permit 16422

Keith Dunton's (permit 16422) research would take place in Long Island Sound, New York, and New Jersey coasts and proposes to take 285 adult/sub-adult Atlantic sturgeon per year. Notice the third category/row in the table below (Table 28), where Dunton could capture up to 100 in one year not to exceed 300 over five years; if Dunton captures that category's maximum for a year, this would be 325 adult/sub-adults for that given year. Note that this could not occur every year for five years since the takes are capped at 300 over five years. This range is reflected in Table 29.

Table 28: Proposed annual take of Atlantic sturgeon for Permit 16422

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Geographic Location (New York Bight DPS)
Atlantic Sturgeon	Adult/sub-adult	100	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize, Internal sonic tag	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	100	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize, Internal sonic tag; and Fin ray clip	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	100 Total of 300/5yr	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Blood sample; Gastric lavage; Gill biopsy	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	20	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; External/PSAT tag	Long Island Sound, New York, New Jersey Coast
Atlantic Sturgeon	Adult/sub-adult	5	Trawl Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Blood sample; Body tissue biopsy*	Long Island Sound, New York, New Jersey Coast

*Procedure would only be performed on fish exhibiting parasitic copepods in body of sturgeon.

Data for MSA is available for Long Island Sound (Wirgin and King 2011), therefore, we applied this MSA to figure take allocations per DPS. Applying the confidence interval of stock contribution percentages of the Long Island Sound Wirgin and King (2011) MSA to Dunton's proposed annual take yields the following (Table 29) take allocations per DPS.

Table 29. Takes per DPS for permit 16422 using the Long Island Sound MSA.

Source	Atlantic sturgeon Genetic Sample Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16422 Takes per DPS per year
Wirgin and King 2011	Long Island Sound*	Long Island Sound, New Jersey Coast	Gulf of Maine	4.5	12-14 Adult/sub-adult
Presentation			New York Bight	79	218-249 Adult/sub-adult
			Chesapeake Bay	7	19-22 Adult/sub-adult
			Carolina	2.75	8-9 Adult/sub-adult
			South Atlantic	10	28-31 Adult/sub-adult

* The above genetic percentages add up to more than 100%. This is caused by using ranges for each of the individual DPSs and each of the individual river populations within each of the DPSs. Wirgin and King 2011 %'s for Long Island Sound do not add up to 100%. These percentages add up to 103.25, therefore, that percentage was applied when doing ratios.

Permit 16436

Kathryn Hattala's (permit 16436) research would take place in the Hudson River. PR1 proposes to authorize the take of 327 juvenile Atlantic sturgeon in year 1, 352 in years 2 and 3, and 1302 in years 4 and 5. Permit 16436 could also take 200 adult Atlantic sturgeon each year for years 1-5.

Table 30: Proposed take of Atlantic sturgeon for Permit 16436

Species	Life Stage	Proposed Annual Take	Observe Collect Method	Proposed Take Activities	Details	Geographic Location (New York Bight DPS)
Atlantic Sturgeon	Juvenile	260	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample	Project 1 Juvenile Abundance Survey (350-1000 mm) (Year 1-5)	Hudson River
Atlantic Sturgeon	Juvenile	40	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue; Anesthetize; Lavage	Project 1 Juvenile Abundance Survey (350-1000 mm) (Year 1-5)	Hudson River

Species	Life Stage	Proposed Annual Take	Observe Collect Method	Proposed Take Activities	Details	Geographic Location (New York Bight DPS)
Atlantic Sturgeon	Juvenile	2	Gill Net	Unintentional Mortality	Project 1) Juvenile Abundance Survey (Year 1-5)	Hudson River
Atlantic Sturgeon	Adult	150	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue	Project 2: Adult Spawning Stock (>1,000 mm) Characteristics (Year 1-5)	Hudson River
Atlantic Sturgeon	Adult	25	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue; Internal acoustic tag	Project 2: Adult spawning Stock (>1,000 mm) Characteristics (Year 1-5)	Hudson River
Atlantic Sturgeon	Adult	25	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue; External acoustic tag	Project 2: Adult spawning Stock (>1,000 mm) Characteristics (Year 1-5)	Hudson River
Atlantic Sturgeon	Juvenile	25/50*	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; External acoustic tag	Project 3: Age-1 (<350mm) Population Estimate (Year 1-3)	Hudson River
Atlantic Sturgeon	Juvenile	1,000	Gill Net	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue	Project 3: Age-1 (<350mm) Population Estimate (Year 4-5)	Hudson River

*25 age-1 juvenile are proposed to be tagged in year 1 and 50 each in years 2 and 3.

Data for MSA is available for the Hudson River (Fox and King 2011, supplemental data to Wirgin and King 2011), therefore, we applied this MSA to figure take allocations per DPS for take numbers for "adults" referenced as such in Table 30 above. However, Hattala's work involves a significant effort to capture juveniles. Age-1 juveniles are being targeted (as depicted in the lower portion of Table 30), which, due to their age and size (<350 mm) certain to be from the Hudson, their natal river. 350-1000 mm juveniles are also being targeted (as depicted in the top section of Table 30) and, based on Hattala's past reports, we know these to be mostly smaller-sized and possibly age-1 fish with few of them being age-2. Therefore, we did not apply Fox and King's Hudson River data to these juveniles. We assumed these juveniles to be New York Bight DPS fish. Applying the confidence interval of stock contribution percentages of the Hudson River Fox and King MSA to Hattala's proposed annual take of adults, and assigning all juveniles to be NYB DPS fish yields the following (Table 31) take allocations per DPS.

Table 31. Takes per DPS for permit 16436 using Hudson River MSA.

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16436 Takes per DPS per year
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	Hudson River	Gulf of Maine	7	14 Adults
			New York Bight	93	186 Adults years 1-5 327 small juveniles in year 1 352 small juveniles in years 2 and 3 1302 small juveniles in years 4 and 5
			Chesapeake Bay	0	0
			Carolina	0	0
			South Atlantic	0	0

Permit 16438

Hal Brundage 's (permit 16438) research would take place in the upper Delaware River and proposes to take 284 juvenile Atlantic sturgeon per year and 50 early life stages per year. In addition to these captures, up to one juvenile Atlantic sturgeon could suffer harmful injury or perish during the course of the study. The juveniles to be targeted for this study are small juveniles (years 1 or 2) so we assumed they are all from the Delaware.

Table 32: Proposed take of Atlantic sturgeon for Permit 16438					
Species	**Life Stage**	**Proposed Annual Take**	**Observe Collect Method**	**Proposed Take Activities**	**Geographic Location (New York Bight DPS)**
Atlantic Sturgeon	Juvenile	200	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal sonic tag	Delaware River
Atlantic Sturgeon	Juvenile	24	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Blood sample; Laparoscopy	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net, Trammel Net, Trawl Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Gastric lavage	Delaware River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat	Intentional (Directed) Mortality	Delaware River
Atlantic Sturgeon	Juvenile	1	Gill Net, Trammel Net, Trawl Net	Unintentional Mortality	Delaware River

Because of the mesh size used and juvenile size targeted, we assume that all of these smaller juvenile fish will be New York Bight DPS fish. Therefore, we did not need to apply MSA results and expect 335 fish from the New York Bight DPS to be taken each year for the life of this permit.

Permit 16507

Dewayne Fox's (permit 16507) research would take place in the Delaware Bay and adjacent offshore areas and proposes to take 410 Adult/sub-adult, 100 juveniles, and 350 ELS of Atlantic sturgeon per year.

Table 33: Proposed take of Atlantic sturgeon for Permit 16507						
Species	**Life Stage**	**Proposed Annual Take**	**Observe Collect Method**	**Proposed Take Activities**	**Details**	**Geographic Location (New York Bight)**
Atlantic Sturgeon	Early Life Stage (Eggs/ Larvae)	50	Egg Mat	Directed Mortality, (Preserved as laboratory samples)	Project 1: Spawning Site Identification	Delaware Bay and Offshore

Species	Life Stage	Proposed Annual Take	Observe Collect Method	Proposed Take Activities	Details	Geographic Location (New York Bight)
Atlantic Sturgeon	Early Life Stage (Eggs/ Larvae)	300	Egg Mat	Take--Enumerated and returned to river	Project 1: Spawning Site Identification	Delaware Bay and Offshore
Atlantic Sturgeon	Juvenile	100	Gill Net	Measure; Weigh; Photograph; PIT tag; Genetic tissue sample	Project 2: Hydroacoustic Assessment	Delaware Bay and Offshore
Atlantic Sturgeon	Adult/ Juvenile	300	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Project 3: Fishery Independent Monitoring/Coastal Sampling Program	Delaware Bay and Offshore
Atlantic Sturgeon	Adult/ Juvenile	60	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Fin ray sample; Anesthetize; Internal sonic tag[1] Gonad tissue sample	Project 3: Fishery Independent Monitoring/Coastal Sampling Program	Delaware Bay and Offshore
Atlantic Sturgeon	Adult/ Juvenile	50	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Fin ray sample; Anesthetize; Pop-off satellite archival tag[2] Gonad tissue sample	Project 3: Fishery Independent Monitoring/Coastal Sampling Program	Delaware Bay and Offshore

3. Only Atlantic sturgeon >60.0cm fork length would be implanted with a sonic tag.
4. PSAT tags are slated for Year 2 – 5 of the permit.

Data for MSA is available for the Delaware coast (Wirgin and King 2011), therefore, we applied this MSA to figure take allocations per DPS. Early life stages are certain to be from the New York Bight DPS, where they are captured. Therefore, we did not apply MSA for the ELS and categorized them as NYB DPS fish. Juveniles that would be targeted for the hydroacoustic assessment are smaller and most likely age-1 juveniles, so we assumed those all to be NYB DPS fish. Applying the mean of the confidence interval of stock contribution percentages for the Delaware coast (Wirgin and King 2011) MSA to Fox's proposed annual take of adults and larger juveniles yields the following (Table 34) take allocations per DPS.

Table 34. Takes per DPS for permit 16507 using Delaware Coastal MSA.

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16436 Takes per DPS per year
Wirgin and King 2011	Delaware Coast	Delaware Bay and adjacent offshore areas	Gulf of Maine	7	29 larger juvenile/adults
			New York Bight	58	350 ELS 100 juveniles 238 larger juvenile/adults
			Chesapeake Bay	18	74 larger juveniles/adults
			Carolina	0	0
			South Atlantic	17	69 larger juveniles/adults

Permit 16431

Stewart Michels's (permit 16431) research would take place in the lower Delaware River and proposes to take 240 juvenile Atlantic sturgeon per year. Of those 240 takes, one unintentional mortality could occur.

Table 35: Proposed take of Atlantic sturgeon for Permit 16431

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (New York Bight DPS)
Atlantic Sturgeon	Juvenile	150	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal sonic tag	Delaware River
Atlantic Sturgeon	Juvenile	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Gastric lavage	Delaware River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (New York Bight DPS)
Atlantic Sturgeon	Juvenile	30	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip;	Delaware River
Atlantic Sturgeon	Juvenile	1*	Gill Net	Unintentional Mortality	Delaware River

*Not to exceed 1 unintentional mortality over the life of the permit

Because of the mesh size used and juvenile size targeted, we assume that all of these smaller juvenile fish will be New York Bight DPS fish. Therefore, we did not need to apply MSA results and expect 240 fish from the New York Bight DPS to be taken each year for the life of this permit.

Permit 16547

Permit 16547 research would take place in the Chesapeake Bay and its tributaries, the James, York, Rappahannock, Potomac, Patapsco, Patuxent, Chester, Choptank, Nanticoke, Susquehanna, and Pocomoke Rivers, and proposes to take 425 adult/sub-adult, 175 small juvenile, and 25 ELS of Atlantic sturgeon per year. Of those captures, up to two juveniles and/or one adult Atlantic sturgeon could suffer harmful injury or perish during the course of the study.

Table 36: Proposed take of Atlantic sturgeon for Permit 16547

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Geographic Location (Chesapeake Bay DPS)
Atlantic Sturgeon	Adult/ Juvenile	100	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Anesthetize[1]; internal sonic tag; PIT tag; Measure; Photograph or Video; fin clip; Weigh	Chesapeake Bay, MD & VA (All saline portions of Chesapeake Bay including coastal areas measuring above 22ppt salinity)
Atlantic Sturgeon	Adult/ Juvenile	100	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	External sonic tag; PIT tag; Measure; Photograph or Video; fin clip; Weigh	Chesapeake Bay, MD & VA (All saline portions of Chesapeake Bay including coastal areas measuring above 22ppt salinity)
Atlantic Sturgeon	Adult/ Juvenile	75	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	External sonic tag, Floy T-bar; PIT tag; Measure; Weigh; Photograph-Video; Fin clip	Chesapeake Bay & tributaries (James, York, Rappahannock, Potomac, Patapsco, Patuxent, Chester, Choptank, Nanticoke, Susquehanna & Pocomoke).

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Geographic Location (Chesapeake Bay DPS)
Atlantic Sturgeon	Juvenile	25	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	External sonic tag; Floy T-bar; PIT tag; Fin clip Measure; Weigh, Photograph Video	Chesapeake Bay & tributaries (James, York, Rappahannock, Potomac, Patapsco, Patuxent, Chester, Choptank, Nanticoke, Susquehanna & Pocomoke).
Atlantic Sturgeon	Juvenile	150	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph Video; Sample, fin clip; Weigh	Chesapeake Bay & tributaries (James, York, Rappahannock, Potomac, Patapsco, Patuxent, Chester, Choptank, Nanticoke, Susquehanna & Pocomoke).
Atlantic Sturgeon	Adult/ Juvenile	150	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph Video; Sample, fin clip; Weigh	Chesapeake Bay & tributaries (James, York, Rappahannock, Potomac, Patapsco, Patuxent, Chester, Choptank, Nanticoke, Susquehanna & Pocomoke).
Atlantic Sturgeon	Eggs or Larvae	25	Egg mat	Intentional (directed) mortality	Chesapeake Bay & tributaries (James, York, Rappahannock, Potomac, Patapsco, Patuxent, Chester, Choptank, Nanticoke, Susquehanna & Pocomoke).
Atlantic Sturgeon	Adult/ Juvenile	2 Juvenile 1 Adult	Gillnet, trawl, trammel net, fyke, trap nets, and pound nets	Unintentional Mortality	Chesapeake Bay & tributaries, including all fresh and saline riverine and coastal areas.

Data for MSA is available for the Chesapeake Bay (Bartron *et al.* 2007), therefore, we applied this MSA to figure take allocations per DPS for the research taking place in the more saline (22 ppt or greater) portions of the bay. Applying the confidence interval of stock contribution percentages of the Chesapeake Bay from Bartron *et al.* (2007) to permit 16547's proposed annual take of adults and larger juveniles yields the following (Table 38) take allocations per DPS.

The James River is a confirmed spawning river. Given the lack of data specific to the James River, we determined that using data from the Hudson River (next closest confirmed spawning river with MSA analysis) represented the best available information for the James. In using the Hudson data, we assume that the greatest percentage of fish will be from the Chesapeake DPS. We know that the Chesapeake Bay represents an area with extensive mixing, thus, fish from any of the 5 DPSs could be present on the spawning grounds. We determined that using the data from the Hudson, where 93% of the fish are from the NYB DPS and 7% are from a neighboring DPS as a starting point would be appropriate for a confirmed Chesapeake spawning river such as the James. The remaining 7% is broken down between all of the remaining DPSs, with a smaller proportion attributed to the Carolina DPS given that these fish are only rarely documented in any of the data sets. Percentages and take allocations are shown in Table 38.

The York River is suspected to be a spawning river, with YOY having been caught in the York. However, to be consistent throughout our analysis, rivers suspected (but not confirmed) of being

spawning rivers are treated as non-spawning rivers. The work under permit 16547 will examine whether the York is a spawning river. For all other non-spawning rivers targeted in this permit, there is no independent genetic analysis to examine, therefore, we made the decision to apply the Hudson River MSA as a model for these non-spawning rivers. This decision was made based on findings that while not all fish in a particular area originated from that particular DPS, a high percentage of them do stay within close geographic proximity to their DPS of origin. In addition, since we know that the Chesapeake Bay represents an area with extensive mixing, fish from any of the 5 DPSs could be present in adjacent rivers to foraging or other purposes. We determined that using the data from the Hudson, where 93% of the fish are from the NYB DPS and 7% are from a neighboring DPS as a starting point would be appropriate for these rivers that are adjacent to the Chesapeake Bay. We feel that non-spawning rivers within this area could be unique due to the extensive mixing that occurs here. The 7% is broken down between all of the remaining DPSs, with a smaller proportion attributed to the Carolina DPS given that these fish are only rarely documented in any of the data sets. Percentages and take allocations are shown in Table 37.

Table 37. Takes per DPS for permit 16547 using Hudson River and Chesapeake Bay MSAs.

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16547 Takes per DPS per year
Bartron *et al.* 2007	Chesapeake Bay	Chesapeake Bay	Gulf of Maine	2.6	5 Adult/sub-adult
			New York Bight	38.8	79 Adult/sub-adult
			Chesapeake Bay	45.5	92 Adult/sub-adult
			Carolina	1.3	3 Adult/sub-adult
			South Atlantic	10.3	21 Adult/sub-adult
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	James River/ Spawning	Gulf of Maine	2	5* Adult/sub-adult
			New York Bight	2	5* Adult/sub-adult
			Chesapeake Bay	93	209* Adult/sub-adult 175 small juvenile 25 Eggs/larvae
			Carolina	1	2* Adult/sub-adult
			South Atlantic	2	5* Adult/sub-adult

*Due to rounding error, these numbers add up to more than the requested take.

Permit 16375

Permit 16375 research would take place in Albemarle Sound, Cape Fear River Basin, Roanoke River, Chowan River, and proposes to take 200 adult/sub-adult Atlantic sturgeon per year.

Table 38: Proposed Annual Take for Permit No. 16375

Species	Life Stage	Proposed Annual Take	Observe/ Collect Method	Proposed Take Activities	Geographic Location (Carolina DPS)
Atlantic Sturgeon	Adult/ Juvenile	45	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal acoustic tag;	Albemarle Sound, Roanoke & Chowan Rivers
Atlantic Sturgeon	Adult/ Juvenile	55	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Albemarle Sound, Roanoke & Chowan Rivers
Atlantic Sturgeon	Adult/ Juvenile	45	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal acoustic tag;	Cape Fear River Basin
Atlantic Sturgeon	Adult/ Juvenile	55	Gill Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Cape Fear River Basin

For all water bodies targeted in this permit, there is no independent genetic analysis to examine. In the Carolina and South Atlantic DPSs, reference genetic samples are only available for the Albemarle Sound, Savannah, Ogeechee, and Altamaha Rivers. The NEFOP and ASM do not have comparable programs in the southeast, so there are very limited samples available from this area and very limited ability to link back samples that have been taken to spawning rivers.

The Roanoke and Cape Fear Rivers are confirmed spawning rivers within the geographic scope of this permit's research. Given the lack of data specific to the Roanoke and Cape Fear Rivers, we determined that using MSA percentages from the Hudson River (next closest confirmed spawning river with MSA analysis) represented the best available information for these confirmed spawning rivers in permit 16375. The Chowan River is not known to be a spawning river, however, it does share a common estuary (Albemarle Sound) with the Roanoke. In addition, Albemarle Sound is not known to be an area of extensive mixing (like Chesapeake Bay) and we could infer that most fish in the Sound will be traveling to/from the Roanoke and/or Chowan. Therefore, we applied the same Hudson River data to the Chowan River and Albemarle Sound. In using the Hudson data, we assume that the greatest percentage of fish will be from the Carolina DPS. We know that while not all fish in a particular area originated from that particular DPS, a high percentage of them do stay within close geographic proximity to their DPS of origin, especially near their river of origin. We determined that using the data from the Hudson, where 93% of the fish are from the NYB DPS and 7% are from a neighboring DPS as a starting point would be appropriate as a model for these rivers. The 7% is broken down between all of the remaining DPSs, with a smaller proportion attributed to the Gulf of Maine DPS given that these fish are the furthest geographically. Percentages and take allocations are shown in Table 39.

We did not apply the Carolina Coast Survey genetic data, since that data pertains to overwintering fish during a specific season in coastal areas and it would not match temporally. Applying the confidence interval of stock contribution percentages of Wirgin and King's data to permit 16375's proposed annual take of adults and larger juveniles yields the following (Table

39) take allocations per DPS.

Table 39. Takes per DPS for permit 16375 using Hudson River MSA as model.

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16375 Takes per DPS per year
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	substituted for all rivers in this permit	Gulf of Maine	1	2 adult/ sub-adult
			New York Bight	2	4 adult/ sub-adult
			Chesapeake Bay	2	4 adult/ sub-adult
			Carolina	93	186 adult/ sub-adult
			South Atlantic	2	4 adult/ sub-adult

Permit 16442

Bill Post's (permit 16442) research would take place in Santee-Cooper Watershed, Winyah Bay Watershed, Savannah River, ACE Basin watershed, and proposes to take 350 adult/sub-adult Atlantic sturgeon per year and 100 ELS per year.

Table 40: Proposed Annual Take for Permit No. 16442

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (Carolina DPS, South Atlantic DPS)
Atlantic Sturgeon	Adult/sub-adult	100	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample	Santee-Cooper Watershed; and Winyah Bay Watershed
Atlantic Sturgeon	Adult/sub-adult	60	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Internal acoustic tag; Gonad biopsy	Santee-Cooper Watershed; and Winyah Bay Watershed
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat	Directed Mortality	Santee-Cooper Watershed; and Winyah Bay Watershed
Atlantic Sturgeon	Adult/sub-adult	100	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample	Savannah River and ACE Basin Watershed
Atlantic Sturgeon	Adult/sub-adult	90	Gill Net, trawl	Measure; Weigh; Photograph; PIT tag; Dart tag; Genetic tissue sample; Anesthetize; Internal acoustic tag; Gonad biopsy	Savannah River and ACE Basin Watershed
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat	Directed Mortality	Savannah River and ACE Basin Watershed

For all water bodies targeted in this permit, there is no independent genetic analysis to examine. However, since the geographic dividing line for the Carolina and South Atlantic DPSs is in South Carolina, we know that the 50 ELS captured in the Santee-Cooper Watershed; and Winyah Bay Watershed will be from the Carolina DPS, and the 50 ELS captured in the Savannah River and ACE Basin Watershed will be from the South Atlantic DPS. After speaking with Bill Post, we know that his takes will be concentrated in the Savannah, Edisto, and Black and Pee Dee River confluence. The Edisto, Savannah, and Great Pee Dee are all confirmed spawning rivers. Therefore, we made the decision to apply the Hudson River MSA percentages locally to these rivers. This study was difficult to analyze, since there are two DPSs geographically within the

study area. The Edisto and Savannah are within the South Atlantic DPS and the Great Pee Dee is within the Carolina DPS, so we applied the greater MSA percentage accordingly to the respective geographic DPS. We determined that using the data from the Hudson, where 93% of the fish are from the NYB DPS, and 7% are from a neighboring DPS as a starting point would be appropriate as a model for these rivers where take effort is targeted. This decision was made based on findings that while not all fish in a particular area originated from that particular DPS, a high percentage of them do stay within close geographic proximity to their DPS of origin. The 7% is broken down between all of the remaining DPSs, with a smaller proportion attributed to the Gulf of Maine DPS given that these fish are the furthest geographically. Applying the Hudson River MSA percentages to permit 16442 Adults/sub-adults and adjusting for the local DPS yielded the following take allocations (Table 41).

Table 41. Takes per DPS for permit 16442 using Hudson River MSA as a model.

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16442 Takes per DPS per year
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	Great Pee Dee River	Gulf of Maine	1	2 adult/sub-adults
			New York Bight	2	3 adult/sub-adults
			Chesapeake Bay	2	3 adult/sub-adults
			Carolina	93	149 adult/sub-adults 50 ELS
			South Atlantic	2	3 adult/sub-adults
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	Edisto and Savannah Rivers	Gulf of Maine	1	2 adult/sub-adults
			New York Bight	2	4 adult/sub-adults
			Chesapeake Bay	2	4 adult/sub-adults

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16442 Takes per DPS per year
			Carolina	2	4 adult/sub-adults
			South Atlantic	93	176 adult/sub-adults 50 ELS

Permit 16482

Doug Peterson's (permit 16482) research would take place in the Savannah, Ogeechee, Altamaha, Satilla, and St. Marys Rivers, and proposes to take 204 adult and 3270 juvenile Atlantic sturgeon per year and 250 ELS per year. Notice the adult/sub-adult categories/rows in the table (42) below, where Peterson could capture up to a certain number in one year not to exceed a given number over five years; if Peterson captures that category's maximum for a year, this would be 360 adult/sub-adults for that given year. Note that this could not occur every year for five years since the takes are capped over five years. This range is reflected in Table 42 below. Of the fish that are to be captured, up to 5 juvenile and 1 adult Atlantic sturgeon may suffer serious injury or die as a result of this effort.

Table 42: Proposed Annual Take for Permit No. 16482

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (South Atlantic DPS)
Atlantic Sturgeon	Adult/sub-adult	40 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Savannah River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Savannah River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Laproscopy; Internal acoustic tag	Savannah River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Anesthetize; Lavage	Savannah River
Atlantic Sturgeon	Juvenile	910	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue	Savannah River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Lavage	Savannah River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Anesthetize; Internal/External tag	Savannah River
Atlantic Sturgeon	Juvenile	50	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Anesthetize; Fin ray clip	Savannah River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Intentional (Directed) Mortality	Savannah River
Atlantic Sturgeon	Adult/sub-adult	40 Total of 120/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue	Ogeechee River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (South Atlantic DPS)
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Ogeechee River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Anesthetize; Internal acoustic tag Laproscopy; Gonad biopsy	Ogeechee River
Atlantic Sturgeon	Juvenile	60	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Ogeechee River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Ogeechee River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal/External acoustic tag	Ogeechee River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Directed Mortality	Ogeechee River
Atlantic Sturgeon	Adult/sub-adult	60 Total of 180/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue Anesthetize; Fin ray	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Gonad biopsy; Anesthetize; Laproscopy; Internal acoustic tag	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue Anesthetize; Lavage	Altamaha River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (South Atlantic DPS)
Atlantic Sturgeon	Juvenile	1910	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Altamaha River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Altamaha River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal/External acoustic	Altamaha River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Lavage	Altamaha River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Intentional (Directed) Mortality	Altamaha River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Satilla River
Atlantic Sturgeon	Adult/sub-adult	10 Total of 30/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue ; Anesthetize; Gonad biopsy; Laparoscopy; Internal acoustic tag	Satilla River
Atlantic Sturgeon	Juvenile	60	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	Satilla River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	Satilla River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue Anesthetize; Internal/External acoustic	Satilla River

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (South Atlantic DPS)
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Directed Mortality	Satilla River
Atlantic Sturgeon	Adult/sub-adult	20 Total of 60/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	St. Marys River
Atlantic Sturgeon	Adult/sub-adult	10 Total of 30/5yr	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue; Gonad sample; Anesthetize; Laproscopy; Internal acoustic tag	St. Marys River
Atlantic Sturgeon	Juvenile	60	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample	St. Marys River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Fin ray clip	St. Marys River
Atlantic Sturgeon	Juvenile	20	Gill Net, Trammel Net	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; Anesthetize; Internal/External acoustic	St. Marys River
Atlantic Sturgeon	Early Life Stage (Eggs/Larvae)	50	Egg Mat, D-Net	Directed Mortality	St. Marys River
Atlantic Sturgeon	Juvenile Adult	5* 1	Gill Net, Trammel Net	Unintentional Mortality	All Rivers

*Unintentional mortality or serious injury cannot exceed 5 juvenile annually or 1 adult Atlantic sturgeon in all rivers annually.

For all water bodies targeted in this permit, there is no independent genetic analysis to examine except for the St. Marys River. (However, the St. Marys river genetic information began with a very small sample size of 9 fish identified.) The St. Marys River is not known to be a spawning river. The confirmed spawning rivers within the scope of this permit are the Savannah, Ogeechee, Altamaha, and Satilla. We know that the 250 ELS proposed to be captured per year will be from the South Atlantic DPS. Also, due to the size of the juveniles that would be caught for this study, we will assume each juvenile is from the river in which it was captured (and, therefore, from the South Atlantic DPS). The adults captured in the confirmed spawning rivers (Savannah, Ogeechee, Altamaha, Satilla) will be allocated to a particular DPS based on the

Hudson River MSA percentages as a model. We determined that using the data from the Hudson, where 93% of the fish are from the NYB DPS and 7% are from a neighboring DPS as a starting point would be appropriate as a model for these rivers where take effort is targeted. This decision was made based on findings that while not all fish in a particular area originated from that particular DPS, a high percentage of them do stay within close geographic proximity to their DPS of origin. The 7% is broken down between all of the remaining DPSs, with a smaller proportion attributed to the Gulf of Maine DPS given that these fish are the furthest geographically.

The St. Marys River is not known to be a spawning river, so we applied different numbers for the adults/sub-adults to be captured here under the permit. We were given genetic information for the St. Marys river based on the capture of 9 fish. This is a very low sample size, but we still

examined the results since this is the only available information for the St. Marys River. The take allocations are in Table 43.

Table 43. Takes per DPS for permit 16482 using Hudson River and St. Marys River MSAs.

Source	Atlantic sturgeon Collection Location	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA	% of DPS Contribution in Collection Location (MSA)	Permit 16482 Takes per DPS per year
Fox and King 2011 unpublished, supplemental data to Wirgin and King 2011	Hudson River	Savannah, Ogeechee, Altamaha, Satilla Rivers	Gulf of Maine	1	2-3 adults
			New York Bight	2	4-7 adults
			Chesapeake Bay	2	4-7 adults
			Carolina	2	4-7 adults
Peterson, unpublished data			South Atlantic	93	173-307 adults 3170 small juveniles 200 ELS
	St. Marys River	St. Marys River	Gulf of Maine	0	0
	(very small sample size)		New York Bight	0	0
			Chesapeake Bay	11	2-3 adults
			Carolina	0	0
			South Atlantic	89	16-27 adults 100 small juveniles 50 ELS

Permit 16508

Permit 16508 research would take place in the Nassau, St. Johns, and St. Marys Rivers, and proposes to take 60 adult/sub-adult Atlantic sturgeon per year.

Table 44: Proposed Annual Take for Permit No. 16508

Species	Life Stage	Proposed Annual Take	Observe/Collect Method	Proposed Take Activities	Geographic Location (South Atlantic DPS)
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net*	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; External sonic tag	St. Marys River
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net*	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; External sonic tag	Nassau River
Atlantic Sturgeon	Adult/sub-adult	20	Gill Net*	Measure; Weigh; Photograph; PIT tag; Floy/T-bar tag; Genetic tissue sample; External sonic tag	St. Johns River

*=The applicant would use side scan sonar first to locate specimens, and then would deploy gill nets to capture sturgeon

For all water bodies targeted in this permit, there is no independent genetic analysis to examine except for the St. Marys River. However, the St. Marys river genetic information began with a very small sample size of 9 fish identified. As the St. Marys data is the only available information, we utilized it just as we did for the permit above, Permit 16482.

Table 45. Takes per DPS for permit 16508 using St. Marys River MSA.

Source	Atlantic sturgeon Collection Location for MSA done	Permit Collection Location to which MSA is Applied	DPS Stock Contribution Based on MSA results	% of DPS Contribution in Collection Location (MSA)	Permit 16508 Takes per DPS per year
Peterson, unpublished data	St. Marys River	St. Marys, Nassau, and St. Johns Rivers	Gulf of Maine	0	0
	(very small sample size)		New York Bight	0	0
			Chesapeake Bay	11	7 adult/ Sub-adult
			Carolina	0	0
			South Atlantic	89	53 adult/ Sub-adult

Total Takes per DPS for all Permits

After applying MSAs and/or models and calculating takes per DPS for each permit, we calculated total takes of Atlantic sturgeon per DPS for all permits and all life stages. This (Table 47) reflects the total takes per DPS each year for 5 years under these permits.

Table 46. Total Atlantic sturgeon takes per DPS for all permits and all life stages (adult, sub-adult, juvenile, ELS).

DPS	Takes per year for 5 years
Gulf of Maine	1,033-1,036
New York Bight	2,243-2,277 year 1 2,268-2,302 year 2 & year 3 3,218-3,252 year 4 & year 5
Chesapeake Bay	633-640
Carolina	410-414
South Atlantic	4,131-4,282

C. Response Analysis

As discussed in the *Approach to the assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after being exposed to an action's effects on the environment or directly on listed species themselves. For the purposes of consultation, our

assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

Capture

Gillnets and Trammel nets. All Atlantic sturgeon from all twelve permits would be captured by net. In addition, five shortnose sturgeon could be incidentally captured by permit 16547 and 16508 (these researchers do not currently have a shortnose sturgeon directed research permit and will not be tartgeting shortnose in addition to Atlantic sturgeon). Atlantic sturgeon would be captured with anchored gill nets sets fishing off the bottom (usually about 1.8m up from the substrate) and in a variety of depths (but a general range would be from 10-60 feet deep). Gill net mesh size would vary by project, but would commonly be 10-18cm (stretch measure), and would be appropriate for the size (i.e., life stage) of sturgeon targeted. Drift gill nets would also be set on the bottom perpendicular to the prevailing flow and allowed to move with the prevailing flow for a short period of time, depending on the tides, generally between 30 minutes and 1.5 hours. Water quality conditions for drift nets would be the same as for anchored gillnets; however, all drift net sets would be continuously tended because of the risk of gear entanglement or loss of gear. Also, drift gillnets would be pulled immediately if it were obvious a sturgeon or non-target listed animal had been captured.

Trammel nets would typically consist of mesh sizes of 2-4" for the inner panes, and 8-12" in the outer panels, although experimental trammel nets would vary depending on the targeted animal. Netting material would consist of heavy multifilament nylon mesh instead of monofilament or light twine. Trammel nets would be fished in water depths comparable to gill nets. Due to their similarity, the same standardized netting protocol as described above for gill nets would be followed.

Entanglement in nets can result in injury and mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Moser and Ross 1995, Collins *et al.* 2000, Moser et al. 2000 and Kahn and Mohead 2010). However, historically, the majority of sturgeon mortality during scientific investigations has been directly related to netting mortality and as a function of numerous factors including water temperature, low dissolved oxygen concentration, soaks time, meshes size, net composition, and netting experience.

To illustrate, shortnose sturgeon mortality resulting from six similar scientific research permits utilizing gillnetting is summarized in Table 47 below. Mortality rates due to the netting activities ranged from 0 to 1.22%. Of the total 5,911 shortnose sturgeon captured by gill nets or trammel nets, only 23 died, yielding an average incidental mortality rate of 0.39%. However, all of the mortalities associated with these permits were due to high water temperature and low dissolved oxygen (DO) concentrations. Moser and Ross (1995) reported gill net mortalities approached 25% when water temperatures exceeded 28ºC even though soak times were often less than 4 hours.

Table 47. Number and percentage of shortnose sturgeon killed by gill or trammel nets associated with existing scientific research permits.

	Permit Number						
	1051	1174	1189	1226	1239	1247	TOTALS
Time Interval	1997, 1999 – 2004	1999 – 2004	1999, 2001 – 2004	2003 – 2004	2000 – 2004	1988 – 2004	1988-2004
No. sturgeon captured	126	3262	113	134	1206	1068	5909
No. sturgeon died in gill nets	1	7	0	0	5	13	26
Percentage	0.79	0.22	0	0	0.41	1.22	0.44

Under Permit Number 1247, between 4 and 7% of the shortnose sturgeon captured died in nets prior to 1999, whereas between 1999 and 2005, none of the more than 600 shortnose sturgeon gill netted died as a result of their capture. Also, in five years, under Permit Number 1189, none of the sturgeon captured died. Under Permit Number 1174, all seven of the reported shortnose sturgeon mortalities occurred during one sampling event.

The low mortality rates of more recent research are due to mitigation measures implemented in permits by NMFS and researchers (Kahn and Mohead 2010), such as reduced soak times at warmer temperatures or lower DO concentrations, minimal holding or handling time, handling sturgeon with smooth rubber gloves, and treating with an electrolyte bath prior to release. Based on the mitigation measures implemented by researchers since 1999, the effects of capture on sturgeon have been reduced.

Although individual researchers proposed more conservative conditions in their applications to limit stress and mortality of sturgeon due to capture by gill and trammel nets, all agreed to adhere to netting protocols provided by NMFS PR. These would include: (1) constantly monitoring of nets; (2) removing animals from nets as soon as capture is recognized; (3) fishing no more than ten hours in daylight periods only when water temperatures are less than 15^{o}C; (4) using three hour intervals when water temperatures are between 15 and 20 ^{o}C; (5) using two hour intervals when water temperatures are between 20 and 25 ^{o}C; (6) and checking nets every hour at water temperatures between 25 and 28 ^{o}C. Netting activities would cease at 28°C or higher, with one exception noted as follows.

In File 16442, 16482 and 16508 (South Carolina, Georgia and Florida waters) a netting protocol would be authorized where soak times would be reduced to 30 minutes at water temperatures between 28 and 30°C, and/or when DO concentrations were between 4.0 and 4.5 mg/L. While netting under these environmental conditions, researchers would monitor closely the impacts on captured sturgeon, limiting procedures to tagging with PIT and Floy tags, measuring and weighing, as well as handling fish no more than 5 minutes between removing them from the net and release. If stressed, an animal would be allowed to recover for 10-15 minutes before being released; however, if the researcher encountered animals not experiencing rapid recovery when sampled, they would discontinue sampling above 28°C and/or below 4.5 mg/L DO and also consult with NMFS. A summary of all external monitoring would be supplied to NMFS bi-weekly basis whenever fishing under these conditions.

Trawls. All Atlantic sturgeon from all twelve permits would be captured by net. Trawling for juvenile Atlantic sturgeon would similarly be performed in the tidal Delaware River from Artificial Island to Trenton (rkm 79-215) using a 4.9 m otter trawl and/or a 14.6 m yankee trawl (File 16438). Likewise, smaller epibenthic trawls, referred to as "Missouri trawl", would be authorized within the Merrimack River, Massachusetts in Maine Rivers and in South Carolina and Georgia Rivers. Although no trawling for young juvenile Atlantic sturgeon has been attempted in the Merrimack River thus far, the technique has proven successful for capturing juveniles (30.0 cm TL) and adults in the Connecticut River (Savoy and Benway 2004) and YOY pallid and shovelnose sturgeon in the Mississippi River (Phelps *et al.* 2010). Additional modifications of the "Missouri" style bottom trawl to protect small, soft-bodied fish are described by Herzog *et al.* (2005).

Larger otter trawls would be used in offshore environments, primarily on sand bottoms along the coastal areas off Long Island Sound, New Jersey and Delaware (File 16422). The same trawl would also be used in portions of the lower Hudson River. These nets would have a longer headrope than the skiff trawls (25m) and larger mesh (8 or 12cm) and would be equipped with steel doors (6'x4', 739lbs.). Trawl times would be similar (5-20 minutes), but due to the environment, tow speeds would be faster than in the rivers, between 3-3.5 knots. Because of their size, these otter trawls would be mechanically hauled.

Sampling using smaller epibenthic, otter and skiff trawls would take place in tidally influenced estuaries and up-river locations in research described in File Nos. 16526, 16323, 16438, 16547 and 16442. The trawl design proposed in File 16526 and 16442 is a 5.17m epibenthic trawl (referred to as a Missouri trawl); while the gear types proposed in the Connecticut River and estuary (File 16323) and in the Delaware River (File 16438) are 9.7m x 7.0m semi-balloon skiff trawl a 4.9 m otter trawl, respectively. To eliminate impacts from trawling with these smaller trawls, trawls would be operated at slow tows, attached typically to a 20-ft johnboat equipped with a 25-40 hp outboard with 100 to 200 foot towlines. The length of the tow lines would be dependent on water depth (i.e., deeper water required longer towlines). A buoy would be attached to a single 75–100-ft rope line fastened to the cod end of the trawl to assist in retrieval if the trawl became snagged. The trawling location and duration would be limited by water depths less than 0.5 m and bottom snags. The trawls would be deployed and retrieved manually and towed by powering boats in reverse (bow upstream) with continued movement downstream. A standard haul would approximate 300 to 500 feet lasting about 10 to 15 minutes (Gutreuter *et al.*, 1995), though trawl tow times would often be shorter. Trawling speed would vary between 2 to 3.5 knots, and locations trawled would be monitored by using a Sounder/Global Positioning System to limit disturbance of the same substrate during a 24 hour period. Bycatch would be identified and enumerated prior to being released unharmed.

In estuaries and other tidally influenced areas of these systems, sampling with trawls would take place in pre-selected flat shallower areas, taking advantage of current movement and river bends. In other river systems, for example in File 16438 (Delaware River), File 16547 (Chesapeake Bay rivers) and in File16442 (South Carolina Rivers), substrates for optimal trawling would be predetermined free of snags and debris so the disturbance of the bottom and the fish community would be minimized as much as possible. Dovel and Berggren (1983) found such trawling was

effective for collecting juvenile shortnose sturgeon with minimal impact to bottom substrate or EFH.

With regard to impacts from trawling with larger otter trawls in marine areas towed behind larger vessels, sampling is proposed in File 16422 in the late fall and early spring in the near-shore marine and estuarine waters off Connecticut, New York, New Jersey, and Delaware. It is also proposed in the lower Hudson River (File 16436). This trawling gear has been used for the last five years by Stony Brook University, New York, in coastal trawling off the New York and New Jersey coastlines with no apparent impact to bottom structure. The substrate type where this trawling has taken place is described by the USGS East-Coast Sediment Analysis (USGS 2000) as comprised of almost 100% sand bottoms. Because, the impact of the mobile fishing gear on the sandy seabed would be related to both fishing intensity and frequency of trawling (Watling and Norse 1998; Auster and Langton 1999), NMFS considers impacts to the bottom substrate would be very low.

Conditions added to the permit in File 16422 would lessen the impacts of trawling with this gear on the targeted and not-targeted species. These conditions would include: (1) trawling tows would be conducted for durations averaging 5 to 7 minutes, and rarely up to 20 minutes, (2) the towing speeds would range between 2 to 3.5 knots during daylight hours only; (3) should a trawl net become snagged on bottom substrate or debris, it would be untangled immediately to reduce stress on animals potentially captured, as well on bottom substrate; (4) to lessen benthic disturbances, trawl nets would not be towed over the same location more than once in a 24-hour period using a GPS system. Using similar conditions in previous sampling of Atlantic sturgeon with identical equipment, the applicant in File 16422 has not killed or harmed an Atlantic sturgeon.

Pound Net, Fyke Net/Hoop Net. All Atlantic sturgeon from all twelve permits would be captured by net. Shortnose sturgeon may incidentally be taken by one of these nets in the sampling proposed by researchers (File 16547) in Maryland and Virginia waters in the Chesapeake Bay. The gear would fished in accordance with state regulatory code and only in waters allowed seasonally or as otherwise mandated by the state agencies.

Pound nets, fyke/hoop nets and other trap nets would be authorized in File 16547 in the Chesapeake Bay and tributaries, and as otherwise regulated (time and place) by applicable state regulations of Virginia or Maryland. Additionally, because of potential for turtle interaction, these gear would only be used by researchers when sea turtles are not anticipated in the action area (typically when water temperatures are $<18^{o}$C, November through April).

Since fish are trapped, not hooked or gilled, in pound and fyke/hoop nets, NMFS believes that captured sturgeon are less likely to be injured or stressed by them. Although there have been no mortalities of Atlantic sturgeon documented with pound nets or fyke nets in the Maryland Reward Program, these gear would be fished and tended as all other authorized gear in the Proposed Action. Further, all other conditions used to protect sturgeon during research activities, including environmental conditions outlined in Table 3, would govern how Atlantic sturgeon are taken and how often these gear would be checked. Upon consultation with the research and a review of the environmental conditions, NMFS PR may authorize additional holding of an

unstressed captured Atlantic sturgeon for up to 24 hours in a pound net.

Because Atlantic sturgeon would be trapped and not gilled in pound nets, the capture of migrating sturgeon is not expected to result in excessive stress that would result in pre-spawning adults abandoning their spawning runs. If captured, and fish are handled correctly, NMFS expects the level of stress would be low enough to result in no long-term behavioral change. Likewise, the nets would be fished when the prospects of turtle interaction in the Chesapeake Bay or tributaries are low, below 18^{o}C.

Beach Seines. All Atlantic sturgeon from all twelve permits would be captured by net. Beach seines operated from the shore are proposed as a capture method for Atlantic sturgeon in the GOM. This gear is proposed for targeting young of year or juvenile fish foraging along flat sandy areas of rivers and estuaries that are not able to out-swim the hauling action of the seine. The seine is lengthened by long ropes for towing when encircling fish and drawing them to the beach.

Beach seines would be authorized proposed research taking place in the GOM. Typical use of beach seines for sampling larval and young of year fish has been a practice of fishery managers sampling shorelines to indicate recruitment health. Beach seines used to sample young sturgeon would be small mesh nylon nets approximately 30 meters in length with a centered enlarged bag area for gathering the catch. Sampling would occur as described previously by encircling sandy foraging areas of targeted sturgeon. Efforts to minimize impacts to catches would include conditions such as: (1) when drawing the seine's lead line close to shore, animals would not be crowded, and would be pooled in clear waters with minimal turbidity or mud bottoms; (2) all animals would be handled and released within 15 minutes after pooled along the shore (3) bycatch would be released unharmed and minimally handled; (4) areas sampled would not be seined more than once in a 24 hour period; and (5) habitats seined would be characterized by sandy bottoms free of bottom snags.

Based on the past history and experience of researchers using the using the types of gear described in this EA, NMFS does not anticipate long-term adverse effects to Atlantic sturgeon or to other non-target animals over their use.

Expected Response to Capture

As demonstrated above, there is a chance that Atlantic sturgeon or shortnose sturgeon could die in nets, but mitigation measures included in the proposed activities should reduce the risk associated with capture. To limit stress and mortality of sturgeon due to capture, the researchers have agreed to NMFS PR's more conservative recent set of netting conditions. Lastly, related to capture, it is anticipated that spawning runs would not be interrupted due to timing and placement.

Therefore, the capture methodology as proposed is not likely to reduce fitness in individual fish, and therefore the viability of sturgeon populations. By extension, capture is not likely to reduce the viability of Atlantic sturgeon DPSs or shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

Although most fish will not experience reduced fitness, incidental mortality could rarely occur. This is discussed further in the incidental mortality section.

Handling

All Atlantic sturgeon would be handled for length and weight measurements and/or the other proposed methods under this proposed research authorization. Fish would be held in a box for examination, measuring, tissue sampling, and tagging. To weigh, captured Atlantic sturgeon would be placed in a capture sling and suspended from a digital scale. In normal processing of most fish (i.e., those not undergoing additional procedures such as gastric lavage, acoustic tagging, or fin ray sampling), the sling would be lowered over the side of the boat into the water, opened, and the sturgeon allowed to swim away.

Handling and restraining Atlantic sturgeon may cause short term stress responses, but those responses are not likely to result in pathologies because of the short duration of handling. Handling stress can escalate if sturgeon are held for long periods after capture. Conversely, stress is reduced the sooner fish are returned to their natural environment to recover. Signs of handling stress are redness around the neck and fins and soft fleshy areas, excess mucus production on the skin, and a rapid flaring of the gills. Sturgeon are a hardy species, but these fish can be lethally stressed during handling when water temperatures are high or D.O. is low (Moser *et al.* 2000, Kahn and Mohead 2010). Sturgeon may inflate their swim bladder when held out of water (Moser *et al.* 2000, Kahn and Mohead 2010) and if they are not returned to neutral buoyancy prior to release, they will float and be susceptible to sunburn and bird attacks. In some cases, if pre-spawning adults are captured and handled, it is possible that they would interrupt or abandon their spawning migrations after being handled (Moser and Ross 1995).

Expected Response to Handling

Although sturgeon are sensitive to handling stress, the proposed methods of handling fish are consistent with the best management practices recommended by Moser *et al*. (2000) and Kahn and Mohead (2010) and endorsed by NMFS and, as such, should minimize the potential handling stress and therefore minimize indirect effects resulting from handling in the proposed research. To minimize capture and handling stress, the proposed research plans to hold Atlantic sturgeon in net pens until they are processed, at which time they would be transferred to a processing station on board the research vessel. For most procedures planned, the total time required to complete routine handling and tagging would be no more than 15 minutes. Moreover, following processing, fish would be returned to the net pen for observation to ensure full (return to equilibrium, reaction to touch stimuli, return of full movement) recovery prior to release. Therefore, the handling methodology as proposed is not likely to reduce fitness in individual fish, and therefore the viability of the Atlantic sturgeon populations. By extension, handling is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

Passive Integrated Transponder (PIT) Tags

All Atlantic sturgeon captured that are previously unmarked would be marked with PIT tags.

No fish would be double-tagged with PIT tags. Prior to PIT tagging, the entire dorsal surface of each fish would be scanned to detect previous PIT tags. Unmarked Atlantic sturgeon would receive PIT tags by injection at an angle of 60° to 80° in the dorsal musculature (anterior to the dorsal fin). The rate of PIT tag retention would be documented and reported to NMFS in annual reports.

PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996, Skalski *et al.* 1998, Dare 2003), amphibians (Thompson 2004), reptiles (Cheatwood *et al.* 2003, Germano and Williams 2005), birds (Boisvert and Sherry 2000, Green *et al.* 2004), and mammals (Wright *et al.* 1998, Hilpert and Jones 2005). When PIT tags are inserted into animals that have large body sizes relative to the size of the tag, empirical studies have generally demonstrated that the tags have no adverse effect on the growth, survival, reproductive success, or behavior of individual animals (Brännäs *et al.* 1994, Elbin and Burger 1994, Keck 1994, Jemison *et al.* 1995, Clugston 1996, Skalski *et al.* 1998, Hockersmith *et al.* 2003). However, some fish, particularly juvenile fish, could die within 24 hours after tag insertion, others could die after several days or months, and some could have sub-lethal reactions to the tags.

If mortality of fish occurs, they often die within the first 24 hours, usually as a result of inserting the tags too deeply or from pathogen infection. About 1.3% of the yearling Chinook salmon (*Oncorhynchus tshawytscha*) and 0.3% of the yearling steelhead (*O. mykiss*) studied by Muir *et al.* (2001) died from PIT tag insertions after 24 hours. In the only study conducted on sturgeon mortality and PIT tags, Henne *et al.* (unpublished) found that 14 mm tags inserted into shortnose sturgeon under 330 mm causes 40% mortality after 48 hours, but no additional mortalities after 28 days. Henne *et al.* (unpublished) also show that there is no mortality to sturgeon under 330mm after 28 days if 11.5mm PIT tags are used. Gries and Letcher (2002) found that 0.7% of age-0 Atlantic salmon (*Salmo salar*) died within 12 hours of having PIT tags surgically implanted posterior to their pectoral fins, but nine months later, 5.7% of the 3,000 tagged fish had died. At the conclusion of a month long study by Dare (2003), 325 out of 144,450 tagged juvenile spring chinook salmon died, but only 42 died in the first 24 hours.

Studies on a variety of fish species suggest that attachment of tags, both internal and external, can result in a variety of sub-lethal effects including delayed growth and reduced swimming performance (Morgan and Roberts 1976, Isaksson and Bergman 1978, Bergman *et al.* 1992, Strand *et al.* 2002, Bégout Anras *et al.* 2003, Robertson *et al.* 2003, Sutton and Benson 2003, Brattey and Cadigan 2004, Lacroix *et al.* 2005). Larger tags and external tags have more adverse consequences, such as impaired swimming, than smaller tags (Bégout Anras *et al.* 2003, Sutton and Benson 2003).

Expected Response to PIT Tags

PIT tags would be used for permanently marking and identifying individual fish by injecting the tags intramuscularly anterior to the dorsal fin. These biologically inert tags have been shown not to cause problems associated with some other methods of tagging fish, that is, scarring and damaging tissue or otherwise adversely affecting growth or survival (Brännäs *et al.* 1994). As such, the proposed tagging of Atlantic sturgeon with PIT tags is unlikely to have significant impact on the reproduction, numbers, or distribution of these fish. However, there is

one record of young sturgeon mortality within the first 24-48 hours of PIT tag insertion as a result of the tags being inserted too deeply. Henne *et al*. (unpublished) found 14 mm tags injected into smaller shortnose sturgeon caused mortality after 48 hours; also, he inferred from his results that either 11.5 or 14 mm PIT tags would not cause mortality in sturgeon equal to or longer than 330 mm (TL). To address this concern, applicants would use tags of proper size for each fish.

Therefore, the PIT tag methodology as proposed is not likely to reduce fitness in individual fish, and therefore the viability of the Atlantic sturgeon populations. By extension, PIT tagging is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

Floy Tags

Most Atlantic sturgeon captured would also be marked with Floy tags. This tagging method could help make collection of information useful for the assessment of the sturgeon population in the action area. In all captured sturgeon, Floy tags would be anchored in the dorsal fin musculature base and inserted forwardly and slightly downward from the left side to the right through dorsal pterygiophores. After removing the injecting needle, the tag would be spun between the fingers and gently tugged to be certain it is locked in place. During the study, the rate of Floy tag retention would be documented and reported in NMFS annual reports.

Smith *et al.* (1990) compared the effectiveness of dart tags with nylon T-bars, anchor tags, and Carlin tags in shortnose and Atlantic sturgeon. Carlin tags applied at the dorsal fin and anchor tags in the abdomen showed the best retention, and it was noted that anchor tags resulted in lesions and eventual breakdown of the body wall if fish entered brackish water prior to their wounds healing. However, Collins *et al.* (1994) found no significant difference in healing rates (with T-bar tags) between fish tagged in freshwater or brackish water. Clugston (1996) also looked at T-bar anchor tags placed at the base of the pectoral fins and found that beyond two years, retention rates were about 60%. Collins *et al.* (1994) compared T-bar tags inserted near the dorsal fin, T-anchor tags implanted abdominally, dart tags attached near the dorsal fin, and disk anchor tags implanted abdominally. They found that for the long-term, T-bar anchor tags were most effective (92%), but also noted that all of the insertion points healed slowly or not at all, and, in many cases, minor lesions developed.

Expected Response to Floy Tags

The use of Floy tags and PIT tags to mark Atlantic sturgeon are duplicative means to identify captured fish. However, we believe that the practice is not expected to significantly impact sturgeon health. The attachment of tags may cause some discomfort and pain to Atlantic sturgeon. Generally, there is little observable reaction to the injection of PIT tags. However, the injection of Floy tags may result in more noticeable reactions than the injection of PIT tags. There is also a greater potential for injury from the insertion of Floy tags than PIT tags because the tag is typically interlocked between interneural cartilage. Injury may result during attachment, although the potential for this is seriously reduced when tags are applied by experienced biologists and technicians. Mortality is unlikely for either tag type (PIT or Floy).

Injection of Floy tags into the dorsal musculature, however, may result in raw sores that may enlarge overtime with tag movement (Collins *et al.* 1994; Guy *et al.* 1996). Beyond the insertion site, it is unknown what effects the on fish the attachment of Floy tags may have. We know of no long-term studies evaluating the effect of these tags on the growth or mortality of tagged shortnose sturgeon. Anecdotal evidence recounted in NOAA's protocol (Moser *et al*. 2000) suggests that Floy tags have little impact on the fish because a number of shortnose were recovered about 10-years after tagging although no data are available to evaluate any effects on growth rate. Studies on other species suggest that the long-term effect of injecting anchor tags into the muscle may be variable. Researchers have observed reduced growth rates in lemon sharks and northern pike from tagging, whereas studies of largemouth bass did not depict changes in growth rates (Tranquilli and Childers 1982; Manire and Gruber 1991; Scheirer and Coble 1991).

To lessen known negative impacts described above using the Floy tag, sterile tagging technique would be used and methods would require to subsequently monitor dorsal fin tag sites of recaptured sturgeon for any lesions. Additionally, results of tag retention and fish health would be reported to NMFS in annual reports and as requested by NMFS. If impacts of the Floy tags are other than insignificant, NMFS would reevaluate their use in the permit. Therefore, the Floy tag methodology as proposed is not likely to reduce fitness in individual fish, and therefore the viability of the Atlantic sturgeon populations. By extension, Floy tagging is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

PSAT Tagging

Pop-up satellite archival tags (PSATs) are used to track movements of migratory large marine animals such as sturgeon. PSATs are equipped as an archival tag (or data logger) with a means to transmit the data via satellite. In a lab study conducted by Oregon Division of Fish and Wildlife on green sturgeon, a pop-off archival tag (PSAT) remained attached with no apparent ill-effects for over 8 months (Erickson and Hightower 2007). Seven green sturgeon were tagged with PSATs in the field component of this research; with the exception of one tag with a faulty pin, all PSATs operated as anticipated and transmitted large datasets. The movement data from these fish indicated they behaved in ways similar to tagged sturgeon in other studies (Erickson and Hightower 2007). PSATs have been also used to examine the oceanic movements of Atlantic sturgeon (Erickson *et al.* 2011). Twenty-three adults were tagged with PSATs and released; data from 8 of the tags were not transmitted, likely due to malfunction. All other tagged Atlantic sturgeon were relocated and the PSATs transmitted data (Erickson *et al.* 2011).

Though data is physically stored on the PSAT, the tag's major advantage is that it does not have to be physically retrieved like an archival tag for the data to be available. Location, depth, and temperature data are used to answer questions about migratory patterns, seasonal feeding movements, daily habits, and survival after catch and release, for examples. PSATs bear a strong resemblance to other external satellite tags in function. Part of the PSAT is designed to fall off, leaving a smaller portion of the tag loosely attached to the fish; and those attachments would eventually corrode and the rest of the tag would fall away. Although there have been

some problems reported with tag technology malfunctioning, their similarity to traditional external telemetry tags and the results of studies indicate the use of PSATs would have no significant fitness effects to the Atlantic sturgeon.

Expected Response to PSAT Tags

Results of tag retention and fish health would be reported to NMFS in annual reports and as requested by NMFS. If impacts of PSAT tags are other than insignificant, NMFS would reevaluate their use in the permit. Therefore, the PSAT tagging methodology as proposed is not likely to result in a fitness reduction to an individual Atlantic sturgeon. By extension, PSAT tagging is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the PSAT tag protocols are closely followed.

Genetic Tissue Sampling

Due to complications in assigning each captured Atlantic sturgeon to its DPS of origin, all researchers under all permits would be required to obtain a gentic tissue sample for later processing. Therefore, at a later date each fish can be assigned to a DPS which would further strengthen our knowledge and methods for preassigning takes to DPS.

Immediately prior to each Atlantic sturgeon's release, a small sample (1 cm^2) of soft fin tissue would be collected from the trailing margin of the caudal or dorsal fin using a pair of sharp sterilized scissors. This procedure does not harm Atlantic sturgeon and is common practice in fisheries science to characterize the genetic "uniqueness" and quantify the level of genetic diversity within a population. Tissue sampling does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact. Many shortnose sturgeon researchers have removed tissue samples according to this same protocol with no mortalities; therefore, we do not anticipate any long-term adverse effects to the Atlantic sturgeon from this activity (Wydoski and Emery 1983) and the methodology as proposed is not likely to reduce fitness in individuals or the viability of Atlantic sturgeon populations. By extension, genetic fin clip sampling is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA.

External Sonic Transmitters

Permits 16436, 16547, 16375, 16508 would externally tag captured Atlantic sturgeon similar to methods presented in Heise *et al.* (2004, 2005). Applicants would use Vemco sonic transmitter devices for juveniles and sub-adults limited in size to no more than 2% of a given fish's body weight. (Adults will receive internal transmitters.) These same fish will have also been tagged with PIT and Floy tags.

External transmitters could be shed. Collins *et al.* (2002) showed that hatchery shortnose sturgeon were able to shed 100% of their external transmitters (9 cm long, 1.7 cm diameter) when attached with a wire through the dorsal fin. However, the same researcher reported no external transmitter tags lost when attached to a dart tag using heat shrunk plastic wrap. Counihan and Frost (1999) found no external tags were shed by juvenile white sturgeon after one

to three weeks. Sutton and Benson (2003) reported a 14.4% shedding rate for external tags (2.1 – 4.0 cm), with 27% of the larger tags (3.4 - 4.0 cm) shed.

Higher retention rates of external tags could occur with the use of newer, smaller external tags and successful methods of attachment. Newer, smaller external tags range in size between 18 and 46 mm long and only 7 to 9 mm in diameter. Using 70 to 100 lb test monofilament line, Randall and Sulak (pers. comm. to Jason Kahn, NMFS, 2009) described a method for attaching such tags bound externally to the dorsal fin using lightweight heat shrink electrical splice tubing and five minute, two-part epoxy. These researchers documented over 96% retention rates on Gulf sturgeon during 2005 to 2008 using the following method.

Tag weight relative to fish body weight is an important factor in determining the effects of a tag (Jepsen *et al*. 2002). The two factors directly affecting a tagged fish are tag weight in water (excess mass) and tag volume. Perry *et al*. (2001) studied buoyancy compensation of Chinook salmon smolts tagged with surgical implanted dummy tags. The results from their study showed that even fish with a tag representing 10% of the body weight were able to compensate for the transmitter by filling their air bladders, but the following increase in air bladder volume affected the ability of the fish to adjust buoyancy to changes in pressure. Winter (1996) recommended that the tag/body weight ratio in air should not exceed 2%. Tags of greater sized implants produced more mortality of juvenile Atlantic salmon. There was 60% mortality (3 of 5 fish) with a 32-mm implant and 20% mortality (1 of 5 fish) with a 28-mm implant and 20% mortality (1 of 5 fish) with a 24-mm implant (Lacroix *et al*. 2004). Fish with medium and large external transmitters exhibited lower growth than fish with small transmitters or the control group (Sutton and Benson 2003).

Transmitters could affect fish swimming performance. Thorstad *et al*. (2000) studied the effects of telemetry transmitters on swimming performance of adult farmed Atlantic salmon. These researchers found that swimming performance and blood physiology of adult Atlantic salmon (1021-2338 g, total body length 45-59 cm) were not affected when equipped with external or implanted telemetry transmitters compared with untagged controls. There was no difference in endurance among untagged salmon, salmon with small external transmitters, large external transmitters and small body-implanted transmitters at any swimming speed. Authors cautioned that results of wild versus farmed salmon may be different (Peake *et al*. 1997). However, a similar study using sea-ranched Atlantic salmon found no difference in endurance, similar to the farmed salmon study (Thorstad *et al.* 2000). On the other hand, juvenile Chinook salmon < 120 mm FL with either gastrically or surgically implanted transmitters had significantly lower critical swimming speeds than control fish 1 and 19-23 days after tagging (Adams *et al.* 1998).

Expected Response to External Transmitters

We expect that Atlantic sturgeon exposed to external sonic transmitters would respond similar to the available information presented above. External tags could be shed, but researchers are using newer tags and attachment method that is much improved over older methods. We do not expect mortality to occur as a result of this procedure. We expect that growth rates or swimming performance could be affected. We expect that the needle wounds from threading through the dorsal fin would heal normally, but acknowledge that adverse effects of these proposed tagging

procedures could include pain, handling discomfort, affected swimming ability, and/or abandonment of spawning runs.

All permits externally attaching transmitters (16436, 16547, 16375, 16508) propose to use standardized protocols endorsed by NMFS (Moser *et al*. 2000) which aim to minimize the effects caused by transmitter tags. To ensure the sturgeon can endure the weight of these tags the total weight of all transmitters and tags would not exceed 2% of the fish's body weight. Tags would only be applied when fish are in excellent condition, and would not be attempted on pre-spawning fish, nor in water temperatures greater than 27$_{o}$C or less than 7$_{o}$C. By using proper precautions and techniques described above, these procedures would not be expected to have a significant impact on the normal behavior, reproduction, numbers, distribution or survival of Atlantic sturgeon. Since we do not expect fitness consequences to occur, we believe that external transmitter attachment is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA.

Internal Sonic Transmitters

Permits 16526, 16323, 16422, 16438, 16507, 16547, 16375, 16442, and 16482 propose to use internal sonic transmitters on Atlantic sturgeon via incision, implantation, and suturing. All transmitters would be limited in size to less than 2% of the fish's total weight. Active and passive tracking would follow transmitter attachment.

In general, adverse effects of these proposed tagging procedures could include pain, handling discomfort, hemorrhage at the site of incision, risk of infection from surgery, affected swimming ability, and/or abandonment of spawning runs. Choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al*. 2002).

Survival rates after implanting transmitters in shortnose sturgeon are high. Collins *et al*. (2002) evaluated four methods of radio transmitter attachment on shortnose sturgeon. They found 100% survival and retention over their study period for ventral implantation of a transmitter with internally-coiled antenna. Their necropsies indicated there were no effects on internal organs. Dr. Collins in South Carolina (M. Collins, *pers. comm., November 2006*) has also more recently reported no mortality due to surgical implantation of internal transmitters. Devries (2006) reported movements of 8 male and 4 female ($\geq$ 768 mm TL) shortnose sturgeon internally radiotagged between November 14, 2004 and January 14, 2005 in the Altamaha River. Eleven of these fish were relocated a total 115 times. Nine of these fish were tracked until the end of 2005. The remaining individuals were censored after movement was not detected, or they were not relocated, after a period of 4 months. Periodic checks for an additional 2 months also showed no movement. Although there were no known mortalities directly attributable to the implantation procedure; the status of the 3 unrelocated individuals was unknown (Devries 2006).

Growth rates after transmitter implantation are reported to decrease for steelhead trout. Welch *et al*. (2007) report results from a study to examine the retention of surgically-implanted dummy acoustic tags over a 7 month period in steelhead trout pre-smolts and the effects of implantation on growth and survival. Although there was some influence in growth to week 12, survival was

high for animals > 13 cm FL. In the following 16 week period growth of surgically implanted pre-smolts was the same as the control population and there was little tag loss from mortality or shedding. By 14 cm FL, combined rates of tag loss (mortality plus shedding) for surgically implanted tags dropped to < 15% and growth following surgery was close to that of the controls.

Tag weight relative to fish body weight is an important factor in determining the effects of a tag (Jepsen *et al*. 2002). The two factors directly affecting a tagged fish are tag weight in water (excess mass) and tag volume. Perry *et al.* (2001) studied buoyancy compensation of Chinook salmon smolts tagged with surgical implanted dummy tags. The results from their study showed that even fish with a tag representing 10% of the body weight were able to compensate for the transmitter by filling their air bladders, but the following increase in air bladder volume affected the ability of the fish to adjust buoyancy to changes in pressure. Winter (1996) recommended that the tag/body weight ratio in air should not exceed 2%. Tags of greater sized implants produced more mortality of juvenile Atlantic salmon. There was 60% mortality (3 of 5 fish) with a 32-mm implant and 20% mortality (1 of 5 fish) with a 28-mm implant and 20% mortality (1 of 5 fish) with a 24-mm implant (Lacroix *et al*. 2004). Fish with medium and large external transmitters exhibited lower growth than fish with small transmitters or the control group (Sutton and Benson 2003).

Implanted transmitters could affect fish swimming performance. Thorstad *et al*. (2000) studied the effects of telemetry transmitters on swimming performance of adult farmed Atlantic salmon. These researchers found that swimming performance and blood physiology of adult Atlantic salmon (1021-2338 g, total body length 45-59 cm) were not affected when equipped with external or implanted telemetry transmitters compared with untagged controls. There was no difference in endurance among untagged salmon, salmon with small external transmitters, large external transmitters and small body-implanted transmitters at any swimming speed. Authors cautioned that results of wild versus farmed salmon may be different (Peake *et al*. 2007). However, a similar study using sea-ranched Atlantic salmon found no difference in endurance, similar to the farmed salmon study (Thorstad *et al.* 2000). On the other hand, juvenile Chinook salmon < 120 mm FL with either gastrically or surgically implanted transmitters had significantly lower critical swimming speeds than control fish 1 and 19-23 days after tagging (Adams *et al.* 1998).

Implanted transmitters could affect fish growth. Juvenile Chinook salmon with transmitters in their stomachs (gastrically implanted) consistently grew more slowly than fish with surgically implanted transmitters, fish with surgery but no implanted transmitter, or fish exposed only to handling (Adams *et al*. 1998).

Water temperature has been shown to affect rainbow trout implanted with simulated transmitters. 80 rainbow trout were implanted with simulated transmitters and held at various temperatures for 50 days (10, 15, 20 degrees) (Bunnell and Isely 1999). Transmitter expulsion ranged from 12% to 27% and was significantly higher at 20 degrees C than at 10 degrees C. Mortality ranged from 7 – 25% and was not related to temperature.

Since implantation requires surgery, healing has been described in available information. Several factors can affect obstacles to wound healing in fish including secondary infection and

inflammation. Fish epidermal cells at all levels are capable of mitotic division, and during wound healing there is a loss of the intracellular attachments and cells migrate rapidly to cover the defect and provide some waterproof integrity (Wildgoose 2000). This leads to a reduction in the thickness of the surrounding epidermis and produces a thin layer of epidermis at least one cell thick over the wound, however the process can be inhibited by infection (Wildgoose 2000). Thorstad *et al*. (2000) state that incisions were not fully-healed in 13 of the farmed Atlantic salmon with implanted transmitters; two of these had signs of inflammation. Juvenile largemouth bass implanted with microradio transmitters exhibited short-term (5 days) inflammation around the incision and suture insertion points for both non-absorbable braided silk and non-absorbable polypropylene monofilament, but in the longer term (20 days) almost all sutures were shed and the incisions were completely healed (Cooke *et al*. 2003). Chapman and Park (2005) examined suture healing following a gonad biopsy of Gulf of Mexico sturgeon and found both the absorbable and nonabsorbable sutures to effectively sew the skin after biopsy with all sturgeons surviving surgery and incisions healing 30 days after the intervention. Dummy radio transmitters compounded the inflammatory effect silk sutures had on healing incisions compared with inflammation without transmitters (Wagner *et al*. 2000).

The expulsion or rejection of surgically implanted transmitters has been reported from a number of studies, and has been mentioned as an argument for using externally attached transmitters. It does not appear that expulsion causes further complications or death in fish that manifest this occurrence. Such expulsions often occur shortly after tagging and can lead to premature end of studies. Rates of tag shedding and ways of implant exits depend on species, fish condition, tag weight and environmental conditions (Jepsen *et al*. 2002). There are basically three ways of implant exit; through the incision, through an intact part of the body wall and through the intestine. Trans-intestinal expulsion is rare but has been occasionally reported in rainbow trout (Chisholm and Hubert 1985). Five months after tagging, 20% of juvenile Atlantic salmon had expelled their tags through the body wall, adjacent to the healed incision (Moore *et al*. 1990). No mortality or infection occurred as a result of tag expulsion, and fish continued to mature and behave like the control fish. Expulsion occurred in 13 of 22 rainbow trout tagged with dummy tags coated with paraffin wax within 42-175 days after tagging (Chisholm and Hubert 1985). In another study of rainbow trout, three of 21 fish expelled their tags via body wall without subsequent mortality (Lucas 1989). Tag expulsion by juvenile Atlantic salmon during their study occurred but was not a cause of death (Lacroix *et al*. 2004). Two surgically implanted transmitters were also apparently expelled by Atlantic sturgeon (Moser and Ross 1995). In Kieffer and Kynard's (1993) study, one shortnose sturgeon implanted with a sonic tag rejected its internal tag.

Coating the transmitters has been suggested to vary the rate of expulsion. It has been hypothesized that paraffin coating of the transmitter increases expulsion rate (Chisholm and Hubert 1985). Moser and Ross (1995) reported that retention of surgically implanted tags could be improved for Atlantic sturgeon when the transmitters were coated with a biologically inert polymer, Dupont Sylastic. Additionally, Kieffer and Kynard (*In press*) report that tag rejection internally is reduced by coating tags with an inert elastomer and by anchoring tags to the bodywall with internal sutures. Kieffer and Kynard's fish retained tags for their operational life, and in most cases, lasted much longer (mean, 1,370.7 days).

Expected Response to Acoustic Transmitter Implantation

We expect that Atlantic sturgeon exposed to internal sonic transmitter implantation would respond in a manner similar to the available information presented above. Survival rates are expected to be high with no ill effects on internal organs expected as a result of the transmitters. We do not expect mortality to occur as a result of this procedure, although a few tagged fish from studies reported above have disappeared and their fate was unknown. We expect that growth rates or swimming performance could be affected and that expulsion of the transmitter could occur, although, there have been no mortalities or infections reported to be associated with expulsion. We expect that the surgical wound would heal normally, but acknowledge that adverse effects of these proposed tagging procedures could include pain, handling discomfort, hemorrhage at the site of incision, risk of infection from surgery, affected swimming ability, and/or abandonment of spawning runs. The research methodologies will minimize these risks, as choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al*. 2002).

PR1 proposes to authorize the use standardized protocols endorsed by NMFS (Kahn and Mohead 2010) which aim to minimize the effects caused by internally implanting transmitter tags. To ensure the sturgeon can endure the weight of these tags, a condition would be imposed stating that the total weight of all transmitters and tags would not exceed 2% of the fish's body weight. By using proper anesthesia, sterilized conditions, and the surgical techniques described above, these procedures would not be expected to have a significant impact on the normal behavior, reproduction, numbers, distribution or survival of Atlantic sturgeon and therefore is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA.

Anesthetic

All permits except 16431 and 16508 propose to anesthetize Atlantic sturgeon. Of the permits proposing to use anesthesia, permits 16526 and 16547 could use electronarcosis as an alternative method for anesthetizing sturgeon.

MS-222. Each sturgeon prepared for surgery for procedures requiring anesthetization would be placed in a water bath solution containing buffered tricaine methane sulfonate (MS-222) for anesthetization (Summerfelt and Smith 1990). Concentrations of MS-222 of 50 up to 150 mg/L would be used to sedate sturgeon from induction to a maintenance state of surgical anesthesia for implantation surgery (total loss of equilibrium, no reaction to touch stimuli, cessation of movement, except for opercula movement). Concentrations of MS-222 of up to 50 mg/L would be used to sedate surgeon for gastric lavage.

Because MS-222 is acidic and poorly absorbed, resulting in a prolonged induction time, Sodium bicarbonate (NaHCO3) would be used to buffer the water to a neutral pH. MS-222 is a recommended anesthetic for sturgeon research when used at correct concentrations (Moser *et al.* 2000, USFWS 2008; *but see* Henyey *et al*. 2002, preferring electronarcosis to MS-222). It is rapidly absorbed through the gills and its mode of action is to prevent the generation and conduction of nerve impulses with direct actions on the central nervous system and cardiovascular system. Lower doses tranquilize and sedate fish while higher doses fully

anesthetize them (Taylor and Roberts 1999). In 2002, MS-222 was FDA-approved for use in aquaculture as a sedative and anesthetic in food fish (FDA 2002).

Increased concentrations for rapid induction are recommended for sturgeon followed by a lower maintenance dose concentration. Matsche (2011) evaluated MS-222 as a surgical anesthetic for Atlantic sturgeon and found small induction doses to result in bradychardia, near medullary collapse, elevated signs of stress (plasma cortisol and reddening of the skin) and a generalized hemo-concentration consisting of erythrocyte swelling and increased protein and monovalent ion concentrations. Therefore, Matsche concluded that larger, more rapid induction doses with higher concentrations of MS-222 result in reduced signs of physiological stress.

Another risk associated with employing MS-222 to anesthetize sturgeon is using concentrations at harmful or lethal levels. Studies show short-term risks of using MS-222 to anesthetize sturgeon other than shortnose, but show no evidence of irreversible damage when concentrations are used at precise recommended levels. A study on steelhead and white sturgeon revealed deleterious effects to gametes at concentrations of 2,250 to 22,500 mg/L MS-222, while no such effects occurred at 250 mg/L and below (Holcomb *et al.* 2004). Another study did not find MS-222 to cause irreversible damage in Siberian sturgeon, but found MS-222 to severely influence blood constituents when currently absorbed (Gomulka *et al*. 2008; *see also* Cataldi *et al.* 1998 for Adriatic sturgeon).

The above studies show use risks of MS-222 to other sturgeon species, but also show that irreversible damage could be avoided if researchers use proper concentrations. Pertaining to shortnose sturgeon specifically, studies conducted by Haley 1998, Moser *et al.* 2000, Collins *et al.* 2006, 2008 show success with MS-222 at recommended levels (concentrations up to 150 mg/L).

Effects of MS-222 would be short-term and only affect the target species. MS-222 is excreted in fish urine within 24 hours and tissue levels decline to near zero in the same amount of time (Coyle *et al.* 2004). To increase absorption time and ensure a fast anesthesia process, the applicant will add sodium bicarbonate to buffer the acidic MS-222 to a more neutral pH. Therefore, at the proposed rates of anesthesia, narcosis would take one minute and complete recovery time would range from three to five minutes (Brown 1988).

Studies show that recovery from anesthetic stress is more of a concern than the anesthetic itself, which leaves the body in 24 hours. Scientists have examined physiological responses of other fish species to MS-222. MS-222 has increased stress response in rainbow trout (Wagner *et al.* 2003), channel catfish (Small 2003), and steelhead trout (Pirhonen and Schreck 2003), as indicated by elevated plasma cortisol levels (Coyle *et al.* 2004). Additionally, a comparison of steelhead trout controls to MS-222-treated steelhead revealed an anesthetic stress response regarding feed. Steelhead sampled at 4, 24, and 48 hours after MS-222 exposure fed less than their controlled counterparts (Pirhonen and Schreck 2003). These studies indicate sublethal physiological concerns if duration of exposure is not limited.

Expected Response to MS-222. Due to the fact that the applicants aim to use an induction concentration within the recommended limitations of MS-222 (which are 50 mg/L for gastric

lavage up to 150 mg/l for transmitter implantation and lavage initial sedation) and ensure that fish are anesthetized with a lower maintenance dose of 50 mg/L, NMFS believes that most shortnose sturgeon sedated by MS-222 would be exposed only to minimal short-term risk and should recover to normal. The applicants aim to avoid the possibility of irreversible effects by following concentration recommendations and recovery procedures used in successful shortnose sturgeon diet studies with similar methodologies (Haley 1998, Moser *et al.* 2000, Collins *et al.* 2006, 2008). The applicants have previously been authorized to perform anesthesia under their research permits for shortnose sturgeon studies and have performed anesthesia on Atlantic sturgeon before they were listed. Because MS-222 is acidic and poorly absorbed, resulting in a prolonged induction time, Sodium bicarbonate (NaHCO3) would be used to buffer the water to a neutral pH. At the proposed rate, induction time would be approximately three to five minutes and complete recovery times would range from five to six minutes (Brown 1988). MS-222 would be excreted in fish urine within 24 hours and tissue levels would decline to near zero in the same amount of time (Coyle *et al.* 2004). The applicants seem to address stress concerns by limiting duration of anesthesia to three to five minutes and monitoring recovery in boat-side net pens before releasing fish.

Due to our review of available information, the prior shortnose sturgeon and Atlantic sturgeon anesthetization experience applicants have had, and mitigation measures included in each permit that would minimize anesthetic impacts, we believe that MS-222 anesthesia is not likely to reduce fitness in individuals or reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the appropriate concentrations of MS-222 are used and proposed duration exposure and procedures are closely followed.

Electronarcosis. Electronarcosis is an alternative "anesthetic" method. Electrical current can cause electrotaxis (forced swimming), electrotetanus (muscle contractions), and electronarcosis (muscle relaxation) in fish (Summerfelt and Smith 1990). Due to the varying results that can occur from electrical current, it is important to realize that an ideal anesthetic should induce anesthesia rapidly with minimum hyperactivity or stress (Coyle *et al*. 2004). The electronarcosis state is achieved through the use of electrical current for anesthesia, as electrotaxis and electrotetanus do not result in minimum hyperactivity or stress. Henyey *et al*. (2002) state that electronarcosis is ideal for non-invasive research, but that more research is needed to determine exactly how electronarcosis works. Hartley (1967) states that using straight DC (as opposed to pulsed DC) provides no anesthetic effect, but rather acts to block cerebral messages to the longitudinal efferent nerves to prevent the sensation of pain. Coyle *et al*. (2004) also notes that electronarcosis immobilizes fish but isn't a true anesthetic. The methods in Henyey *et al*. (2002) elicited narcosis, not tetany; Kynard (U.S. Geological Survey, *pers comm.*, December 2008) states that the fish's nerve pathway is blocked at the medulla oblongata.

Recovery time from electronarcosis is shorter than with chemical anesthetics, as fish can swim upright as soon as the electricity is turned off (Summerfelt and Smith 1990). As soon as the sturgeon is placed in, or is removed from the electrical current, several researchers have reported immediate narcosis or recovery (Gunstrom and Bethers 1985; Summerfelt and Smith 1990; Henyey *et al*. 2002). 95% of white sturgeons exposed to electronarcosis recovered immediately in a study by Holliman and Reynolds (2002).

When compared to chemical anesthetics, such as MS-222, electronarcosis shows significant benefits, such as this short recovery time. Evaluations comparing anesthesia induced using MS-222 and electrical narcosis have yielded similar results of muscle relaxation and immobility (Kynard and Lonsdale 1975; Henyey *et al.* 2002); however, a marked increase in induction and recovery time was experienced when using MS-222 compared to electronarcosis. Juvenile lake and shortnose sturgeons immobilized with 80 mg/L of tricaine took a significantly longer time to orient than control fish or fish immobilized with electricity for 5 or 30 minutes (Henyey *et al.* 2002). Induction and recovery from electronarcosis both take less than one minute while induction and recovery takes place in 3-5 minutes and 5 to 7 minutes respectively with MS-222. Factors such as size and water temperature can influence electronarcosis. Larger fish are more rapidly electronarcotized than smaller ones, with larger sturgeon becoming immobilized at lower voltages than smaller sturgeon (Coyle *et al*. 2004, Henyey *et al.* 2002). Electronarcosis has been shown to be most effective when water temperatures are between 10 and 25^{o}C (Henyey *et al*. 2002).

Physiological effects or effects on reproduction have been little-studied on sturgeon, however a few studies reveal these effects of electronarcosis on other fish. For northern pike, survival of eggs from fertilization to eye-up did not significantly differ between eggs collected from electronarcotized adults and adults anesthetized with MS-222 (Walker *et al*. 1994). Juvenile bull trout exposed to continuous- or pulsed-DC electroshock exhibited rapid elevations in plasma cortisol and glucose, but plasma chloride did not change (Barton and Dwyer 1997).

Previous studies employing electronarcosis on sturgeon have yielded good results. Since Henyey *et al*. (2002) published their methods, permit 14617 applicants began using similar electronarcosis techniques (since 2004) on the Potomac River and Chesapeake Bay anesthetizing shortnose and Atlantic sturgeon. Internal transmitter tags were surgically implanted under electronarcosis with no adverse affects reported (Mike Mangold, USFWS, *pers comm*., January 2009). In another study in South America, researchers followed similar methods and reported similar results (Alves *et al.* 2007). Henyey *et al*. (2002) also used this method in the lab and monitored shortnose sturgeon for 6 weeks following electronarcosis measuring no adverse effects in that time. No change in swimming or feeding behavior, and no burns or bruising of the skin or mortalities were seen (Henyey *et al*. 2002). Furthermore, Kynard (application for Permit 1549) reported several years of data showing no mortality following anesthetization with electronarcosis.

Expected Response to Electronarcosis. We expect that Atlantic sturgeon undergoing electronarcosis would respond similarly to the research revealed above. The risk associated with electronarcosis is over-applying the direct current causing cessation of opercula movement and involuntary respiration. However, NMFS believes that with proper training this method is safe for inducing narcosis and, if used carefully on green, shortnose, and Atlantic sturgeon, there is very little chance of mortality or harmful injury. Therefore, the electronarcosis methodology as proposed is not likely to reduce the viability Atlantic sturgeon populations. By extension, tissue sampling is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as proposed methods are closely followed.

Laparoscopy

Permits 16438, 16482 would conduct laparoscopic surgery on Atlantic sturgeon. Laparoscopy is a minimally invasive surgery (MIS), or an operation performed through small incision(s) compared to larger incisions needed for traditional surgeries. In comparison to most traditional surgical procedures, MIS induces relatively minor tissue trauma, which, in most cases, results in shorter postoperative recovery periods, decreased postoperative care, and fewer postoperative complications (Cook and Stoloff 1999). Laparoscopy is used in fish species to qualitatively assess morphological health and to visually identify the sex and maturity status of study fish accurately. Laparoscopy can begin in two different ways. The procedure could be done by cutting a small incision in the fish's body cavity and inserting an endoscope to view gonads or other internal organs (Hernandez-Divers *et al*. 2004, Moccia *et al*. 1984, Swenson *et al*. 2007, Wildhaber *et al*. 2005). The endoscope can also be inserted through the urogenital pore, which avoids having to make an incision (Kynard and Kieffer 2002, Ortenburger *et al*. 1996). For laparoscopy using an incision entry point, a trocar is sometimes used. The trocar acts to "guide" the endoscope into the fish through the incision, and protects the incision from further tear. Endoscopes may also be flexible or rigid. The rigid 42 endoscope always requires a straight path to the organs being examined whereas the flexible endoscope may give and bend (Dover and Van Bonn 2001). Finally, insufflation with a gas is used to provide the visual internal space needed for effective examination with the endoscope.

After immobilized with MS-222 (effects of anesthesia are analyzed in a separate section), animals would be positioned in lateral recumbency on a portable surgical table. Researchers would make a 5 mm incision in the ventral body wall slightly off midline at a level midway between the pectoral girdle and the cloaca. A 5 mm trocar would then be inserted through the incision and a 5 mm rigid endoscope would be inserted through the trocar. If necessary, the body cavity would be insufflated with ambient air by attaching a battery-powered air pump to an insufflation port on the trocar.

When compared to other methods, laparoscopy has been shown as an accurate method for determining the sex of fish from the Acipenseridae and Salmonidae families. Swenson *et al*. (2007) utilized laparoscopy to correctly determine the maturity status and sex of mature individuals for 96% of the eastern brook trout examined in their study. The percentage was determined by euthanizing trout after laparoscopy for dissection and comparing results of the two methods. Wildhaber *et al*. (2005) assessed the effectiveness of ultrasound versus laparoscopy for sex determination of shovelnose sturgeon by verifying results with histological analysis. These researchers found that the success of the method used for sex determination was dependent upon its invasiveness, whereby laparoscopy was more effective than ultrasound.

Within laparoscopy technique, inserting the endoscope through the urogenital pore for sex determination is not as consistent as sex determination of endoscopy through incision (shovelnose sturgeon; Wilhaber *et al*. 2005). Introduction of the endoscope through the urogenital pore was not difficult in female arctic char, but resulted in accidental rupture of the spermatic duct in some of the males (Ortenburger *et al*. 1996). Furthermore, Kynard and Kieffer (various sturgeon species; 2002) observed an unpredictability of urogenital opening size based on length of fish. They recommended choosing an endoscope with small rather than large

diameter. To avoid this unpredictability, it could be prudent to utilize an incision, rather than urogenital pore insertion, to create a predictable opening and therefore the endoscope diameter could properly be chosen.

Many studies comment on the absence of injury or other evident damage from laparoscopic procedure and report it to be a relatively safe procedure when carried out carefully. It is reported that laparoscopy does not harm reproductive structures, does not cause internal damage such as bruising or infection, and does not cause hemorrhage or buoyancy problems. Kynard and Kieffer (2002) reported that careful use of an endoscope will not harm reproductive structures and is suitable for all sturgeon species. They also report that endoscopes inserted through the urogenital pore will not damage the female oviduct valve. Moccia *et al*. (1984) noted that necropsy of rainbow trout maintained under controlled lab conditions revealed no evidence of internal damage from a previous endoscopic procedure, such as internal bruising or infection. They also note that gross healing of the surgical incision is 70% complete in 7 – 10 days, without signs of inflammation or other damage even without antibiotics. Hernandez-Divers *et al*. (2004) reported that no morbidity or mortality occurred as a result of laparoscopy to Gulf of Mexico sturgeon as there was no significant hemorrhage or trauma associated with any fish. Furthermore, they also noted that no postoperative swimming or buoyancy problems (i.e. swim bladder injury) were observed in their study.

Laparoscopy post-procedure mortality is reported in the literature for Salmonidae, and has been attributed to small fish size and coincident chronic gill disease infection. Swenson *et al*. (2007) reported a 3.3% post-procedure mortality for laparoscopy of eastern brook trout, which was limited to trout smaller than 70 mm FL. These fish were from the smallest class size Swenson *et al.* (2007) examined for their study and therefore they hypothesized that smaller individuals may be at greater risk from laparoscopy than larger fish. They suggested this could be due to the fact that the procedure may have taken longer for small fish because it was more difficult to view internal organs. Orgenburter *et al*. (1996) reported that 2 of the arctic char that underwent laparoscopy in their study died compared to none in the control group. This was attributed to severe chronic gill disease and no signs of peritonitis or inflammation of the coelomic viscera were found on necropsy and subsequent histological examination of deceased fish (Ortenburger *et al*. 1996). These researchers were ultimately unable to definitively relate deaths to the procedure described – because both deceased fish had survived for more than 5 days following procedure and were diagnosed as having severe degenerative gill disease at the time of death (Ortenburger *et al*. 1996).

It has also been suggested that stresses incurred during the procedure and delayed complications, as well as increased susceptibility to predation after release, could also contribute to mortality. Moccia *et al*. (1984) suggested that incidental loss of epidermal mucus, increases in body temperature, drying of the skin, or a combination of these factors could contribute to eventual mortality in fish that undergo laparoscopy, but their previous laboratory studies indicate this is unlikely. Although immediate mortality may be low post-laparoscopy, we should not rule out the possibility of delayed complications from laparoscopy, such as reopening of the incision, infection, and injury to internal organs (Swenson *et al.* 2007). Accidental perforation of the caudal air bladder was known to have occurred in 3 of the 70 arctic char evaluated by Ortenburger *et al*. (1996). Ecchymotic hemorrhages were seen on microscopic evaluation of the

tissue surrounding the genital pore only in female arctic char that had ovulated and hemorrhage appeared to be associated with oviposition rather than introduction of the endoscope (Ortenburger *et al*. 1996). Inflammatory infiltrates were only seen surrounding the genital pore in male arctic char, and may indicate disruption of the normal communication of the vas deferens (Ortenburger *et al*. 1996). The blind and forced puncture of an endoscopic cannula and trocar into the coelom can potentially cause visceral bruising or perforation and researchers used a threaded design for gradual advancement by rotation to avoid bruising (Hernandez-Divers *et al*. 2004). The use of insufflation pressure greater than 4-8 mm Hg could compromise circulation, especially venous return, in fish with lower arterial and venous blood pressures (Hernandez-Divers *et al*. 2004). Fish released into wild settings after laparoscopy may be more susceptible to these and other sources of related mortality, such as subsequent predation (Swenson *et al*. 2007).

Further study is needed to evaluate the long-term lethal and sublethal effects of endoscopy in natural settings and there is still a need to document the continued fertility of fish subjected to endoscopy. However, studies of radio tagging, a procedure that is more invasive than endoscopy, suggest that these problems are minimal. For example, radio tags in largemouth bass and dummy acoustic transmitters in juvenile Atlantic salmon had few long-term effects on fish in the wild (Cooke *et al*. 2003, Lacroix *et al*. 2004).

Expected response to laparoscopy

We expect that the Atlantic sturgeon exposed to laparoscopy would respond similarly as revealed in the literature above. We do not expect to see significant hemorrhage or trauma associated with the procedure. We also do not expect postoperative swimming problems. Finally, the post-procedure mortality seen in Salmonidae has been attributed to small fish size and gill infection. Laparoscopy would only be conducted on adults. We expect that a large majority of the Atlantic sturgeon that undergo this procedure would not have fin infections.

Available information reports that laparoscopy is safe when carried out carefully. NMFS' evaluation of the laparoscopy under this action reveals that the CIs under the proposed permit have trained many other researchers at the Warm Springs National Fish Health Center and have routinely performed similar procedures on shortnose sturgeon and Atlantic sturgeon without complication.

The procedures would increase the risk of complications associated with the added stress of the surgical procedures and the extended time under anesthesia. Because the sutures used to close the laparoscopy sites penetrate the body wall, they would also provide a route of possible infection. To combat this, as small an incision as possible would be used, which would minimize the amount of suture necessary and decrease the healing time. Finally, suture ties would be kept as short as possible and disinfectant would be applied to the sutures prior to recovering the animal from anesthesia. This treatment would help prevent fungal growth on the sutures that could possibly infect the animal prior to healing of the incision wounds. We expect that the small incision and insertion of the laparoscope would have little probability of killing or producing sub-lethal effects as healing is rapid, although delayed complications are possible.

Therefore, we believe the laparoscopy methodology as proposed is not likely to reduce fitness in individual fish, or in the viability of the Atlantic sturgeon populations. By extension, laparoscopy is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the protocols are used and closely followed.

Borescopy

Permits 16526 and 16482 propose to contuct a borescopic examination of Atlantic sturgeon. Borescopic examination has proven an effective method for sexing sturgeon using fiber optic technology. Kynard and Kieffer (2002), Wildhaber and Bryan (2006), and Wildhaber *et al.* (2006) described the technique using a flexible borescope on shortnose, pallid, and shovelnose sturgeon where the head and body of the fish is examined under a lightly anesthetized condition. This procedure, lasting one to two minutes, is conducted with a flexible fiber optic endoscope (16cm long x 4mm diameter) inserted carefully through the urogenital opening and into place within the urogenital canal (Kynard and Kieffer 2002). Sampled females are verified by positively identifying eggs through the urogenital wall. Developed eggs are staged as either "early stage" or "late stage" individuals to identify potential spawners for the coming spring. This is done by carefully comparing the coloration and separation of oocytes viewed through the urogenital wall. Undeveloped eggs are often almond or cream-colored and sometimes indistinguishable from male testes, while mature eggs appear darker, separated, and well formed. It is noted that there are variations of this technique using a trocar to first pierce the genital canal to view and/or biopsy the gonads with an inserted fiber optic borescope; however, NMFS does not recommend this procedure on listed sturgeon.

The above borescope is easily passed through the urogenital opening (average 7.6mm) of adult shortnose, juvenile Atlantic, and other sturgeon species, although there are no similar morphological data for green sturgeon reported. Van Eenennaam *et al.* (2008) have suggested that the diameter of the urogenital canal of green sturgeon is smaller than other sturgeon species. The greatest potential for injury with this procedure, according to Kynard and Kieffer (2002), is internally at the juncture of the oviduct and urogenital canal, located approximately 9 to 20% of a sturgeon's body length from the vent, regardless of species. The borescope must be maneuvered carefully beyond the oviduct to clearly see and stage eggs. However, when using a 16 cm borescope, the probe tip will reach beyond the oviduct in most sturgeon of one meter length or less. Further, Kynard and Kieffer (2002) reported that repeated probing of the oviduct valve by 4-mm and smaller diameter probes did not penetrate the oviduct valve or damage the urogenital canal regardless of species or fish length. They concluded that careful use of a properly sized borescope would not harm reproductive structures and would be suitable for most sturgeon species.

Kynard and Kieffer (2002) examined 443 sturgeon adults using a boroscope over six years. Of those, 173 were identified as female and 270 were unidentified — either as females with immature eggs or identified as males. However, Wildhaber *et al.* (2006) was able to correctly identify 85% (93% accurate for males, 63% for females) of shovelnose and pallid sturgeon examined using a similar borescope. During their work, Wildhaber and Bryan (2006) and Wildhaber *et al.* (2006) did not document any injuries or mortalities associated with borescope activities.

Borescopy requires less time than more invasive surgery, making it a safer alternative to laparoscopy (described above) for field use when handling large numbers of sturgeon under adverse conditions. However, the borescope has limited ability to distinguish between females with immature eggs and male fish.

Expected Response to Borescopy

We expect that Atlantic sturgeon would respond similar to what is reported in the literature. Borescopy would have less probability of producing sub-lethal effects than laparoscopy, although delayed complications are possible. Since borescope use does not require incision, healing time will be much quicker than is expected for laparoscopy. Therefore, the capture borescopic examination as proposed is not likely to reduce fitness in individual fish, and therefore the viability of the Atlantic sturgeon populations. By extension, borescopy is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the protocols are used and closely followed.

Gonad Biopsy

Permits 16422 and 16442 propose to conduct gonad biopsy. In some cases during laparoscopy, the sex of the fish is not readily apparent, so biopsies of the gonadal material could be taken for a definite sex determination. Upon completion of the biopsy, the body cavity and biopsy site would be visually assessed to ensure that there was no obvious hemorrhaged or herniated tissue requiring additional attention. The incision would be sutured with a single suture in a cruciate pattern using PDS suture material.

Gonad samples do not cause disruptive hemorrhaging of the sampled site because of the lack of blood vessels in the vicinity of the sampled site. Further, sturgeon seem to return to completely normal behavior within a day or 2 after surgery (Jefferies, *pers. comm*., 2005). Hernandez-Divers *et al.* (2004) conducted laparoscopic sex determinations, gonadal biopsies (5 mm sample taken) and various reproductive surgeries on hatchery-reared Gulf of Mexico sturgeon. The five male sturgeon that received gonadal biopsies survived the surgery and the authors concluded that the surgery was minimally invasive, safe and effective.

Because no formal studies of sublethal effects of gonadal biopsies on sturgeon exist we looked to similar studies for insight. Studies conducted by Ritchie (1965, 1970) evaluated the effects of gonadal biopsies on the survival and the survival and recapture rates of striped bass, respectively. Ritchie (1965) conducted biopsies on 20 wild fish (10 age 2 fish and 10 age 3 fish) while in the lab. The gonads were accessed through the urogenital pore and fish were not fed for the duration of the experiment to produce uniform stress and magnify any effects caused by the biopsies. Fish were also not anesthetized. All fish were sacrificed and received necropsies at the end of the experiment. At necropsy, 15% of the fish had unhealing gonad wounds (three fish), one of which was considered to be serious. Tests to determine the survival between the groups of fish were inconclusive. Ritchie (1970) conducted field tests of the effects of gonadal biopsy using the same procedures as in Ritchie (1965) on the survival of tagged striped bass. The author concluded that the biopsies did not alter the survival rate or the travel habits of the striped bass.

Expected Response to Gonad Biopsy

We believe that gonad biopsy would have a minimal impact on the Atlantic sturgeon sampled. Previous researchers have indicated that biopsy surgery is safe and effective and gonad samples do not have potential to cause disruptive hemorrhaging at the sample site. Studies conducted on other fish species reveal that survival rate after biopsy is either not altered, or has a very low incidence of chronic unhealed wound sites.

Therefore, biopsy as proposed is not likely to reduce the viability of the Atlantic sturgeon populations. By extension, biopsy is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the proposed methodology and proposed mitigation measures are closely followed.

Blood Sampling

Blood would be collected from the caudal veins of Atlantic sturgeon sampled in permits 16526, 16422, 16438, and 16482. This would be achieved by inserting a hypodermic needle perpendicular to the ventral midline at a point immediately caudal to the anal fin. The needle would be slowly advanced while applying gentle negative pressure with the syringe until blood freely flows into the syringe. Once a blood sample is collected, direct pressure would be applied to the site of to ensure clotting and prevent further blood loss (Stoskopf 1993).

Venipuncture is a simple way of drawing blood from sturgeon. Venipuncture is nonlethal and is not expected to have any sub-lethal effects (Klinger *et al.* 2003). Effects of drawing blood samples with syringes from the caudal vein of sturgeon could include pain, handling discomfort, possible hemorrhage at the site or risk of infection. To mitigate these effects, the needle would be slowly advanced while applying gentle negative pressure to the syringe until blood freely flows into the syringe. Once the blood is collected, direct pressure would be applied to the site of venipuncture to ensure clotting and prevent subsequent blood hemorrhaging (Stoskopf 1993). The site would then be disinfected and checked again after recovery prior to release. Additionally, all of the researchers responsible for obtaining these samples will have received extensive experience in the procedure.

Expected Response to Blood Sampling

As stated above, venipuncture is non-lethal and we do not expect this method to have sub-lethal effects or reduction in fitness. We acknowledge that pain, handling discomfort, possible hemorrhage at the site or risk of infection could occur, but procedure mitigation efforts (such as pressure and disinfection) lessen those possibilities. We believe that drawing blood in the manner described appears to have little probability of killing shortnose sturgeon or producing sub-lethal effects as long as the procedure is conducted by a qualified veterinarian or experienced biologist.

Therefore, blood sampling as proposed is not likely to reduce the viability of the Atlantic

sturgeon populations sampled. By extension, blood sampling is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the proposed methodology and proposed mitigation measures are closely followed.

Fin Ray Section

Permits 16526, 16323, 16422, 16507, 16431, and 16482 would sample Atlantic sturgeon fin rays. A small section (~1 cm^2 notch), of the leading pectoral fin ray would be collected on sampled fish, and no other invasive procedure (such as gastric lavage or implantation) would be performed on fish undergoing fin ray sectioning. The recommended method requires researchers, using a hacksaw or bonesaw, to make two parallel cuts across the leading pectoral fin-ray approximately 1cm deep and 1cm wide. The blade of the first cut is positioned no closer than 0.5cm from the point of articulation of the flexible pectoral base to avoid an artery at this location (Rien and Beamesderfer 1994, Rossiter *et al.* 1995, Collins 1995, Collins and Smith 1996). The second cut is made approximately 1cm distally (Everett *et al.* 2003, Fleming *et al.* 2003, Hurley *et al.* 2004, Hughes *et al.* 2005), where a pair of pliers is then used to remove the fin-ray section.

Studies on the effects of fin-ray sampling have progressed throughout the years. Results have fluctuated and indicate mortality, abnormal enlargement of secondary fin-rays, and no significant differences in swim ability or growth. Kohlhorst (1979) first reported potentially deleterious effects of pectoral fin-ray sampling, including mortality, associated with fin-ray removal from white sturgeon during a mark recapture study. However, the mortality noted by Kohlhorst could have been influenced by small sample size. Nevertheless, the concern of mortality triggered additional laboratory research by Collins (1995) and Collins and Smith (1996). Using methods removing the entire ray (as opposed to a small section) from the base, Collins and Smith found that wounds healed quickly and the pectoral fin-rays behind the leading spine "bulked up" (growing in circumference) and later appeared similar to the original fin-ray. Further, there were no significant differences in growth or survival between treatment and control sturgeon. In other laboratory studies testing fin-ray function, Wilga and Lauder (1999) concluded that pectoral fins are used to orient the body during rising or sinking, but are not used during locomotion. Following Wilga and Lauder's discovery, Parsons *et al.* (2003) removed pectoral fin-rays from shovelnose sturgeon and placed the fish in tanks to test sturgeons' ability to hold position in currents. Without fin-rays, sturgeon were able to hold their positions in a current as well as the control sturgeon. Most recently, while conducting mark and recapture surveys of Atlantic and shortnose sturgeon, Collins *et al.* (2008) discovered that some secondary fin-rays on larger mature sturgeon had enlarged abnormally when the sturgeon were recaptured (after having t their entire fin-ray removed). It was thought this growth could potentially be detrimental to the affected sturgeons' health when removing the entire fin-ray. At this point, Collins' team decided to no longer remove entire fin-rays from adult sturgeon, reasoning that this condition was related to slower growth in larger adult fish.

Despite some difficulties documented in age validation of sturgeon (especially for older mature fish) (Rien and Beamesderfer 1994, Paragamian and Beamesderfer 2003, Hurley *et al.* 2004, Whiteman *et al.* 2004), age determination using marginal fin-rays could be a viable, non-lethal means to obtain necessary information on growth, recruitment, and mortality of shortnose

sturgeon when generating population estimates, and is also valuable when detecting a shift or bottle-neck in recruitment. Although original procedures resulted in some mortality, modern research shows no difference in growth or swimming ability between controls and sampled fish; at most, modern research shows that secondary fin-rays could enlarge abnormally in larger mature sturgeon.

Expected Response to Fin Ray Section

The fin-ray sampling procedure would be expected to cause short-term discomfort to individuals, but it is not expected to have a significant impact on the survivability or the normal behavior of individuals. To minimize adverse effects, the samples would be collected using sterilized surgical instruments to remove the 1 cm sections of pectoral fin-rays while fish are under anesthesia and the entire fin-ray would not be removed. Additionally, no other research method requiring anesthesia (e.g., gastric lavage, or tag implanting) would be conducted on the same fish selected for fin-ray sectioning. Finally, each researcher authorized to conduct fin-ray sectioning would be required to have had training in the procedure. Therefore, the methodology as proposed is not likely to reduce the viability of Atlantic sturgeon populations. By extension, fin ray sampling is not likely to reduce fitness in individuals or the viability of Atlantic sturgeon DPSs as listed under the ESA.

Gastric Lavage

Permits 16422, 16436, 16438, 16431, and 16482 propose to conduct gastric lavage on Atlantic sturgeon. Researchers would be using methods described by Haley (1998), Murie and Parkyn (2000), Savoy and Benway (2004), and Collins *et al.* (2008). The applicants have been previously authorized to conduct gastric lavage on shortnose sturgeon with no mortalities or apparent ill effects. The applicants have also conducted gastric lavage on Atlantic sturgeon prior to listing.

Gastric lavage has recently provided information on diets and how they relate to seasonal foraging and habitat use (Foster 1977, Haley 1998, Murie and Parkyn 2000, Moser *et al.* 2000) and can provide useful information aiding to the designation of critical habitat. Due to the morphology of the sturgeon gut tract and position of its swim bladder, care must be taken in the procedure to not injure sturgeon while inserting the tube into the esophagus. Potential injury to sturgeon could include abrasion of the gut wall near the pyloric caecum, trauma associated with not introducing the tubing properly in the gut, and potential negative growth responses of sturgeon (going off-feed) after gastric lavage.

To mitigate these risks the applicants propose to use polyethylene rather than aquarium (rigid) tubing, as the latter type of tubing has produced ruptured bladders and bleeding from the vent (Sprague *et al.* 1993). Additionally, a specific tubing diameter (3.2 mm outside diameter; 2.4 mm inside diameter) will be utilized because it is recommended for sturgeons with total lengths (350 mm FL and above) that will be caught for the study (Collins *et al*. 2008). Finally, the Applicants are anesthetizing sturgeon with MS-222 prior to gastric lavage, which relaxes the gut wall. Lavage procedures without anesthesia have revealed constriction of the alimentary canal

(Wanner 2006), so anesthetic relaxation should permit easier penetration of tubing to a proper position in the gut.

The gastric lavage procedures associated with the proposed permits would follow methods published by Haley (1998). None of the 46 adult or 2 juvenile shortnose sturgeon or 28 Atlantic sturgeon that Haley (1998) subjected to the procedure died or exhibited adverse responses to the procedure under her methods. In studies utilizing Haley's method modified with the garden sprayer instead of syringe, the same successful results were observed (Collins *et al.* 2006, 2008).

Further review of the literature shows gastric lavage on sturgeon with Haley's methodology to be a relatively well-tolerated procedure. Moser *et al*. (2000) conducted a study in which they reviewed the most acceptable sampling and handling methods of shortnose and Atlantic sturgeon, including gastric lavage. They concluded the method set forth by Haley (1998) to be a safe and effective technique because of flexible tubing and anesthesia. Savoy and Benway (2004) reported results from 246 shortnose sturgeon collected on the Connecticut River between 2000 and 2003. All of the fish tolerated their procedure well and recovered without apparent stress. M. Collins has also reported zero mortality in the field (M. Collins, pers. com., Nov 2006) on Atlantic sturgeon and shortnose sturgeon. Between 2006 and 2008 Collins *et al.* (2008) captured and lavaged 198 Atlantic and 20 shortnose sturgeon using Haley's method modified with a garden sprayer. All fish recovered rapidly and were released unharmed after the procedure. The lavage technique was successful in evacuating stomach contents effectively of both Atlantic and shortnose sturgeon of all sizes without internal injury. Additionally, recaptured sturgeon (lavaged an average of 76 days between recapture), experienced typical interim weight gains indicating that the procedure did not negatively influence sturgeon growth. Collins also compared responses of shortnose in captivity to wild fish and found no weight difference from their response to lavage (Collins *et al*. 2006). Of 327 sturgeon collected by Connecticut Department of Environmental Protection investigators from 2000 through 2002, 246 sturgeon were subjected to gastric lavage under Permit No. 1247 (Savoy and Benway 2004). Of these, 17 shortnose sturgeon were subjected to the procedure twice while 2 sturgeon were subjected to the procedure three times. The shortest interval between lavages for a single fish was four days, although the average time between events was 138 days. None of the shortnose sturgeon in that sample died or had physiological or sub-lethal effects that appeared likely to reduce the short- or long-term fitness of the individuals that were exposed to this procedure.

Lavage results on all species of sturgeon are similar. None of the 20 Siberian sturgeon (*Acipenser baeri*) that Brosse *et al*. (2002) lavaged died as a result. However, most of them did experience biologically-significant weight losses for up to 60 days following the procedure. Guilbard *et al.* (2007) followed the methods of Brosse (modified with electric pump) and lavaged Atlantic and lake (*Acipenser fulvescens*) sturgeon with success. Nellis *et al.* (2007) lavaged 41 Atlantic and 98 lake sturgeon using the Guilbard technique, and did not report complications with the procedure. In 2007, Savoy lavaged 41 Atlantic sturgeon using Haley's method with no apparent complication. Shuman and Peters (2006) conducted a pulsed gastric lavage study on shovelnose sturgeon (*Scaphirhynchus platorynchus*) and found no significant difference between their control group and the lavaged group. Wanner (2006) evaluated a gastric lavage method without anesthesia on juvenile pallid sturgeon (*Scaphirhynchus albus*) in

which he found no significant difference in condition and growth in length (between the control and lavage groups).

Negative effects reported in the literature on species other than Atlantic sturgeon include weight loss, mortality, internal organ injury, and a discontinuation of the lavage procedure altogether. No such effects are described upon literature review for Atlantic (or shortnose) sturgeon. As stated above, most of the Siberian sturgeon in Brosse's (2002) study did experience biologically significant weight losses for up to 60 days following procedure. Sprague *et al.* (1993) conducted lavage on white sturgeon with rigid aquarium tubing and no anesthesia. These researchers experienced 33% mortality of white sturgeon in the study and also observed ruptured bladders and bleeding from the vent on surviving white sturgeon. Farr *et al*. (2001) quit their lavage procedure on green sturgeon entirely, having been unable to successfully pass tubing past the first bend in the alimentary canal.

Literature review reveals gastric lavage following Haley's (1998) methodology to be tolerated relatively well by sturgeon. Although death and other complications have occurred in the literature with white, green, and Siberian sturgeon, no such complications have been published for Atlantic (or shortnose) sturgeon. Experienced gastric lavage researchers working with shortnose sturgeon such as Haley (1998), Brosse *et al*. (2002), Savoy and Benway (2004), and Collins *et al*. (2006, 2008) have experienced no mortality in the field. Savoy and Benway (2004) even lavaged 17 shortnose sturgeon twice and two shortnose sturgeon three times with no apparent ill effects.

Expected Response to Gastric Lavage

Injuries occurring as a result of gastric lavage in non-Atlantic sturgeon studies such as ruptured bladders, bleeding from the vent, and weight loss seem to be addressed by applicants. Ruptured bladders and bleeding from the vent were observed in a study that used rigid aquarium tubing and no anesthesia (Sprague *et al*. 1993). Finally, the weight loss of Siberian sturgeon in Brosse *et al*.'s (2002) study is challenged by the results of Collins *et al*. (2006) (shortnose sturgeon) and Wanner (2006) (pallid sturgeon) showing results that indicate lavage did not negatively influence sturgeon growth.

Applicants would follow successful methods that utilize soft flexible tubing and anesthesia (MS-222), in order to aid tubing down into the gut thereby avoiding bladder rupture and other injury. In order to avoid results of Farr *et al*. (2001) (unsuccessful passage of tubing past first bend in alimentary canal), the applicants have been previously authorized to conduct gastric lavage on shortnose sturgeon (and have conducted lavage on Atlantics prior to listing) and have performed the procedure with no mortalities or apparent ill effects that have been reported.

Based on our review of available information, training applicants have, and precautions that will be taken to minimize anesthetic impacts, we believe that gastric lavage is not likely to reduce the fitness in individuals or reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as the appropriate protocols are used as proposed.

Gill Biopsy and Expected Response to Gill Biopsy

Permit 16422 would conduct gill biopsy on captured Atlantic sturgeon. Gill biopsies are generally done to ascertain the presence/absence of parasites. Parasites like to attach to gill areas due to accessible blood source (Fast *et al*. 2009; Munroe *et al*. 2011). Atlantic sturgeon sampled in 2007 and 2008 in the New York Bight were examined for the presence of external parasites and there were no reports on ill effects due to gill biopsy (Fast *et al*. 2009).

Researchers would biopsy the *outer* portion of the gill (not the *inner* portion where bloodflow is greatest). Each sample would be 2 mm in size. This is similar to what is found in the literature and we did not uncover evident ill effects in the literature as a result of this methodology. We expect Atlantic sturgeon who will undergo gill biopsy to respond similar to fish in the literature and we do not expect them to suffer a fitness consequence.

Hydroacoustic Equipment

Permits 16526, 16507, 16438, 16375, and 16508 would use side scan and/or DIDSON sonar gear for locating sturgeon before setting gill nets for capture. The use of hydroacoustic assessment is a non-invasive method. Researchers use it to collect information without physically capturing fish. Used in conjunction with netting specific target animals, it could potentially lead to less impact on the target fish, as well as bycatch, while reducing the length of time an animal would be ensnared in a net, and thus minimizing potential for harm. Hydroacousic equipment used under these permits will not be within a hearing range of Atlantci sturgeon. Thus, we believe that the use of hydroacoustic equipment is not likely to reduce the viability of Atlantic sturgeon as listed under the ESA.

ELS Samples

Permits 16526, 16438, 16507, 16547, 16442, and 16482 would use D-mats or sleds to collect early life stages. Two hundred ELS from the Gulf of Maine DPS, 400 ELS from the New York Bight DPS, 25 ELS from the Chesapeake Bay DPS, 50 ELS from the Carolina DPS, and 350 ELS from the South Atlantic DPS would be taken each year. Because of their large size, female Atlantic sturgeon are extremely fecund. Fecundity of female Atlantic sturgeon has been correlated with age and body size, with observed egg production ranging from 400,000 to 4 million eggs per spawning year (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). Female gonad weight varies from 12–25 percent of the total body weight (Smith, 1907; Huff, 1975; Dadswell, 2006). Therefore, the fecundity of a 770-pound (350 kg) female, like the one captured in the St. John River, Canada, in 1924, could be 7–8 million eggs (Dadswell, 2006).

The survival from egg to juvenile is likely the most critical aspect in determining the strength of the year class (COSEWIC 2005). Therefore, it is important to be conservative when analyzing the impacts of removing eggs and larvae from the river systems. For that reason, if only 1 female Atlantic sturgeon reproduces each year in the Gulf of Maine (GOM) DPS and produces a minimal number of eggs (400,000), this project would collect approximately 0.05% of the eggs produced in that year from the GOM DPS. As such, the annual proposed take of 200/400,000

eggs or larvae from the GOM DPS could have minimal effects on the Atlantic sturgeon populations in this DPS. Similarly, if only 1 female Atlantic sturgeon reproduces each year and produces a minimal number of eggs (400,000) in the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs, the proposed action would collect 0.10%, 0.006%, 0.01%, and 0.08% of the eggs produced in that year from each DPS, respectively. As such, the annual proposed take of ELS from all DPSs would have minimal effects on those Atlantic sturgeon populations.

Past tracking research has documented likely spawning migrations of gravid female sturgeon to potential spawning sites. If the presence of spawning activity can be confirmed, the location of spawning areas and the timing of the spawn would be important for future recovery planning and protection. The collection of ELS would likely result in more timely and conclusive data pertaining to sturgeon spawning.

Expected Response due to Collection of ELS

We do not expect the collection of the proposed amounts of ELS annually from the GOM, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs to impact the ability of Atlantic sturgeon to survive. Even if one gravid female were to produce eggs on the low end of her estimated scale (400,000 to 4 million eggs), the proposed take would be a minimal 0.006%-0.08% of that one female's total annual spawning production. Therefore, the ELS collection methodology as proposed is not likely to reduce the viability of the Atlantic sturgeon populations in these DPSs. By extension, the collection of ELS per year as proposed is not likely to reduce the viability of Atlantic sturgeon DPSs as listed under the ESA. This conclusion can be reached as long as proposed methods are closely followed.

Incidental/Unintentional mortality

Incidental mortality of adult or juvenile Atlantic sturgeon would be authorized throughout the life of the permit since some of the research methods could result in fish death. Specifically, in years 1-5 of the targeted research, 6 juveniles and 1 adult from the New York Bight DPS, 2 juveniles from the Chesapeake Bay DPS, and 5 juveniles and 1 adult from the South Atlantic DPS would be authorized for take via incidental mortality. This is due to the fishing effort of applicants in certain river systems where it is believed that large numbers of Atlantic sturgeon are present. Applicants would be required to document any lethal takes of Atlantic sturgeon by completing a sturgeon salvage form and any specimens of body parts must be preserved until sampling and disposal procedures are discussed with NMFS. There are currently no other NMFS-issued permits allowing incidental mortality of juvenile or adult Atlantic sturgeon on the eastern seaboard. Commercial and recreational fisheries do not target Atlantic sturgeon, although they have some Atlantic sturgeon bycatch.

There are no population estimates for rivers in the Gulf of Maine DPS. However, we can look to qualitative information to provide river-specific information. Three hundred and thirty-six Atlantic sturgeon (nine adults and 327 sub-adults) were captured in the Kennebec River in a multi-filament gill net survey conducted intermittently from 1977-2000 (Squiers 2004). During this period, the CPUE of Atlantic sturgeon had increased by a factor of 10-25 (1977 – 1981

CPUE = 0.30 versus 1998 – 2000 CPUE = 7.43). An intensive gill net survey was conducted in the Merrimack River from 1987-1990 to determine annual movements, spawning, summering, and wintering areas of shortnose and Atlantic sturgeon (Kieffer and Kynard 1993). Thirty six Atlantic sturgeon were captured (70-156 cm total length). Most of these fish were under 100 cm total length, suggesting that these were all sub-adult sturgeon (Kieffer and Kynard 1993).

The Hudson River is believed to have the largest population in the New York Bight DPS, and is estimated to have 870 spawning adults per year (Kahnle *et al.* 2007). Relative abundance sampling reveal captures of 562 juveniles over two years (Sweka *et al.* 2006).

There are no population estimates for rivers in the Chesapeake Bay DPS. However, we can look to qualitative information to provide river-specific information. Within the Chesapeake Bay, the U.S. Fish and Wildlife Service has been funding the Maryland Reward Program since 1996. This program has resulted in the documentation of approximately 1,700 Atlantic sturgeon. Five hundred sixty seven of these fish were hatchery fish, of which 462 were first time captures (14% recapture rate), and the remaining 1,133 were wild fish. Virginia also instituted an Atlantic sturgeon reward program in the Chesapeake Bay in 1997 and 1998 (ASSRT 2007). This reward program documented and measured 295 Atlantic sturgeon.

The Altamaha River is believed to have the largest population in the South Atlantic DPS, and is estimated to have 343 spawning adults per year (Schueller and Peterson 2006). Estimates for juveniles in the Altamaha are 1,072 to 2,033 individuals (Schueller and Peterson 2010).

Since we do not know the population sizes of each Atlantic sturgeon DPS, we need to be conservative when estimating the removal of quantities of fish from each of the DPSs. If we act conservatively and take the lower estimate of each DPS population size, the small number of incidental mortalities that would be authorized for the proposed action will most likely have an insignificant effect to the overall populations. Even if the populations were as small as quantitative reports, the removal of these fish from the populations would be minimal at this level. Since all other research methods as proposed are not likely to result in a fitness reductions for individuals, NMFS believes that the allowance of these incidental mortalities, when considering other external incidental mortalities, is unlikely to reduce the viability of the listed DPSs as listed under the ESA.

Sea Turtle Incidental Captures

Two of the permits included in this action (permits 16547 and 16482) are expected to incidentally capture 2 turtles each for a total of 4 turtles under the entire proposed action (either leatherback, loggerhead, green, hawksbill, or Kemp's ridley). We evaluated the effects of incidental netting capture to sea turtle species and found that sea turtles exhibit short-term physical and physiological manifestations with evidence of long-term effects to the fitness of some individuals. In the following section, we outlined typical responses of sea turtles for all species examined in this Opinion. We also outlined factors that could influence the way in which a sea turtle may respond to capture or various factors influencing the intensity of capture effects. We found that a percentage of sea turtles may die as a result of capture, either in the net or upon

post-release. The preceeding section 2 (Species' Response to Effects of Capture) examines each species' response as a result of the removal of turtles from the population.

Effects Resulting from Capture. A sea turtle can experience effects that are either sublethal or lethal when it is captured in a gillnet, and there are multiple factors that influence severity of capture effects. Capture could cause physical injuries such as restricted access to air, intense struggling, injuries to soft tissue or the shell, and physiologic injuries such as induction of a systemic stress response, hypoxia, or various other changes in blood chemistry (Gregory *et al.* 1996, Boettcher 2000, Jessop *et al*. 2004). Finally, when a turtle is so entangled that it cannot breathe properly or cannot reach the surface for air, the turtle can drown as a result of forced submergence (Sasso and Epperly 2006).

Physical Injuries. Physical injuries have been observed during scientific studies. Turtles in North Carolina that Snoddy and Williard (2010) recovered post-release had injuries due to barnacles on the soft tissue being ripped off by the gillnet. Another turtle was seen to have some pink inflammation and pink markings from the gillnet (Snoddy and Williard 2010). Snoddy *et al.* (2009) classified all sea turtles caught in their gillnets according to physical grade A through D based on reflex response level, activity level, and presence-absence and severity of net-inflicted physical external injuries. Out of 18 turtles captured, most were physical grade B (medium activity level, all reflexes present and good, minor injuries) and C (medium activity level, missing or delayed reflexes, moderate injuries).

Factors Making Sea Turtles Prone to Capture Injuries. There are many factors that make sea turtles prone to capture injuries. Sea turtles are particularly prone to entanglement as a result of their body configuration and behavior. Records of stranded or entangled sea turtles reveal that fishing debris can wrap around the neck or flipper, or body of a sea turtle and severely restrict swimming or feeding. Sea turtles may also experience constriction of appendages as a result of the entanglement. Constriction may cut off blood flow, causing deep gashes, some severe enough to remove an appendage.

Factors Influencing Intensity of Capture Injuries. Some factors may influence the intensity of effects resulting from capture, such as the size or species of the turtle, ambient water temperature, and multiple submergences. Larger sea turtles are capable of longer voluntary dives than small turtles, so juveniles may be more vulnerable toentanglement stress. Larger turtles have a larger lung capacity than smaller turtles and, the bigger the turtle, the greater chance it has of reaching the surface after being entangled. Larger turtles are more susceptible to injury if dropped on deck or when coming into contact with the vessel while in the water (Ryder *et al*. 2006). Leatherbacks could be more vulnerable to injury than other species because of their friable skin, softer tissue, bone structure, and increased susceptibility to anoxia (Ryder *et al*. 2006). During the warmer months, routine metabolic rates are higher, so the impacts of the stress due to entanglement may be magnified at that time.

Wounds and Wound Healing. Turtles that receive entanglement injuries must go through a period of wound healing, during which they may become more susceptible to other injuries or stressors. The injury healing process may affect the physiological stress response. Concentrations of circulating corticosterone were significantly different between loggerheads with healing

injuries and their controls (Alderson 2009). Loggerheads show a high resiliency to injuries, as most injuries examined by Alderson (2009) in a study were found to be predominantly healed.

Physiological Injuries/Stress. Capture may result in profound physiological changes which are detectable by analysis of blood chemistry. Since sea turtles rely on anaerobic metabolism during periods of activity, struggles to escape fishing gear would likely result in the build-up of lactate, metabolic acidosis, and changes in ion concentrations in sea turtles' blood that could have deleterious effects on normal physiological function (Stabenau *et al.* 1991, Hoopes *et al*. 2000, Harms *et al*. 2003, Stabenau and Vietti 2003). In addition, an increase in the adrenal steroid hormone corticosterone could result (Aguirre *et al*. 1995, Gregory *et al*. 1996, Jessop *et al.* 2004). The presence of elevated levels of heat shock proteins (HSP) in sea turtle blood may also be indicative of the degree of stress experienced by turtles as a result of capture (Southwood and Swimmer 2006).

Sea turtles that are forcibly submerged undergo respiratory and metabolic stress that can lead to severe disturbance of their acid-base balance. Sea turtles subjected to forced submergence exhibit alterations in blood lactate concentration indicative of metabolic acidosis, as well as shifts in blood ion concentrations (sodium, chloride, and potassium) indicative of disruptions in cellular homeostasis compensation for respiratory acidosis (Stabenau *et al*. 1991, Harms *et al*. 2003, Stabenau and Vietti 2003, Snoddy *et al*. 2009).

Factors Intensifying Physiological Injury/Stress. It is likely that the rapidity and extent of the physiological changes that occur during forced submergence are functions of the intensity of struggling as well as the length of submergence (Lutcavage and Lutz 1997). As an example, increased entanglement time and decreased physical grade account for an increase in plasma lactate and glucose (Snoddy *et al*. 2009). In addition, elevated levels of phosphorous found in sea turtle blood can indicate tissue damage, since inorganic phosphates leak out of damaged cells and into the bloodstream (Bishop *et al.* 2004). Hypoxia and restraint from entanglement can cause changes in sea turtle blood chemistry. They can exhibit a decrease in blood pH (Harms *et al.* 2003). Gregory *et al.* (1996) noted a 3-fold increase above control values for plasma corticosterone, a hormone which indicates stress.

Post-Release Vulnerability. Sea turtles become very vulnerable after release, which could lead to additional stress or even mortality. Prolonged anaerobiosis due to entanglement in fishing gear or restraint may leave sea turtles exhausted and vulnerable to other threats upon release from gear (Snoddy *et al*. 2009). These sea turtles subjected to forced submergence may require extended periods of time at the surface to rest, recover, and repay oxygen debt (Stabineau and Vietti 2003). Severe disruption of physiological homeostasis and induction of the systemic stress response may result in alterations of normal diving and foraging patterns and leave sea turtles susceptible to other threats, such as predators, boat strikes, and further encounters with commercial fisheries (Southwood and Swimmer 2006). Finally, capture and handling activities could have markedly affected a turtle's metabolic rate (St. Aubin and Geraci 1988), reproduction (Mahmoud and Licht 1997), and hormone levels (Gregory *et al.*1996).

Factors Affecting the Intensity of Post-Release Vunerability. Many factors can affect the intensity of post-release vulnerability. Entanglement time, depth of entanglement, and severity of

entanglement may have an effect on the health status of turtles upon release from a gillnet and effect probability of post-release survival (Snoddy *et al.* 2009). Turtles are probably more susceptible to lethal metabolic acidosis if they experience multiple captures in a short period of time, because they would not have had time to process lactic acid loads (*in* Lutcavage and Lutz 1997).

Post-Release Recovery Descriptions. Although it appears that entanglement netting can result in temporary changes in blood chemistry of sea turtles and other vulnerabilities, it also appears that animals immediately placed back into a marine environment after removal from the gear can recover from the short-term stress of capture (Hoopes *et al.* 2000). Some researchers report that the effects of the entanglement and forced submergence are expected to dissipate within a day (Stabenau and Vietti 1999). Hoopes *et al*. (2000) conclude that entanglement netting is an appropriate "low stress" method for researchers working on turtles in shallow, coastal areas. Capturing sea turtles in nets is stressful to the turtle, however this stress does not always appear to be life threatening. Sublethal effects that might have an impact on sea turtles are loss of growth, delayed development, diminished productivity, and delayed time to maturity. These remain very different to quantify with the amount of information available. Sublethal effects might outweigh lethal effects due to impacts at the population level, but these effects are uncertain.

Post-Release Mortality. Sea turtles caught in shallow water gillnets (such as those to be used in the proposed actions) are frequently released alive, however their fate remains uncertain. The incidence of in-net mortality for turtles caught in shallow-set gillnets is low compared with deep-set gillnets (Gearhart 2001, Price 2005). It is speculated that sea turtles caught in shallow-set gillnets are still capable of reaching the surface to breathe and therefore the risk of drowning in the nets is reduced (Gearhart 2001). However, there is the possibility that turtles may get the bottom of the net tightly wrapped around their neck or flipper, preventing them from reaching the surface - even in a shallow net. Observer reports and data from fishermen indicate that most sea turtles released from shallow gillnets are typically released alive (Gearhart 2001). However, their fate after release remains unknown. Injuries and physiological stresses occurring as a result of net entanglement could lead to post-release mortality (Lutcavage and Lutz 1991, Harms *et al*. 2003, Stabenau and Vietti 2003, Snoddy *et al*. 2009).

Rates of sea turtle post-release mortality have not yet been adequately quantified, and available estimates remain controversial. Current estimates are based on a combination of known recorded mortality, cessation of transmissions from satellite tags, and captive studies where captured turtles were placed in tanks and turtles were observed over time (longline capture, Aguilar *et al.* 1995). The range of available post-release mortality estimates for *longline* entanglement or hooking is extremely variable and reported at 8-95% post-release mortality (Swimmer *et al*. 2002). The range of available post-release mortality estimates for *gillnet* entanglement in North Carolina (Cape Fear River) could be as low as 7.1% and as high as 28.6% (Snoddy and Williard 2010).

Snoddy and Williard (2010) studied movements and post-release mortality of juvenile sea turtles released from gillnets in the lower Cape Fear River, North Carolina. In their study, 14 juvenile green and Kemp's ridley turtles were satellite tagged in the Cape Fear River and tracked to

decipher post-release mortality within the first 30 days after release from shallow water gillnets (set for 4 hours). The study also combined a blood biochemistry analysis by taking blood samples prior to release. Mortalities were either confirmed (located the carcass), suspected (displayed satellite transmission patterns indicative of mortality), or survivors (did not display satellite transmission patterns indicative of mortality). There was one confirmed mortality, three suspected mortalities, and 10 survivors. Snoddy and Williard estimate that post-release mortality from 4-hour-soaked shallow water gillnets could be as low as 7.1% and as high as 28.6%. Blood samples were also taken prior to release in order to determine if confirmed or suspected dead turtles had different values for plasma concentrations. The confirmed mortality had a very high plasma lactate concentration compared with baseline values reported in literature, producing a plasma concentration of Na^+ that was approximately two times the mean of suspected mortalities and survivors, a plasma concentration of Cl^- that was approximately three times higher than the mean for suspected mortalities and survivors, and the highest plasma concentration of K^+ in the study. This difference was not statistically significant, probably due to low sample size.

Expected Post-Release Mortality. Assessing the extent of non-lethal capture effects on individual turtles is difficult. The limited observer information makes it difficult to estimate the survival rate for entangled turtles. However, only active turtles that appear healthy would be released. The permit would require the resuscitation of comatose turtles and the transfer of turtles to rehabilitation facilities if necessary. This required treatment and care if needed would be expected to minimize the chances of post-release mortality.

After examining the available post-release mortality estimates for gillnets in the action area, we determined that the best available estimates are from the Snoddy and Williard (2010) study described above. We decided to err on the side of caution in analyzing the effects of the research using Snoddy and Williard's high range post-mortality estimate (28.6%), to assume that approximately 30% of the captured turtles could be expected to die post-release. While the fishery and net soak time of the Snoddy and Williard's study (where the 30% figure came from) is not identical to the ones that would be involved in the issuance of these permits, it is similar and use of 30% represents a reasonable, conservative estimate based on available knowledge. Therefore, applying the 30% and conservatively rounding would mean that about 1 sea turtle (either loggerhead, leatherback, green, Kemp's ridley, or hawksbill) could die post-release as a result of the proposed action. The following response section analyzes the species' response as a result of the potential removal of these numbers of species from their populations.

Capture Response Summary. In conclusion, we expect sea turtles to respond similarly to the literature reported above. We expect that capture could result in physical or phyisiological injury or stress responses to individual turtles. A number of factors, such as size, species, water temperature, severity of entanglement, and others can intensify the effects resulting from capture. Some turtles may die as a direct result of being entangled in the net, or some time after release (post-release mortality). NMFS expects that, while most turtles will suffer none or short-term injuries and recover relatively quickly, some turtles are estimated to perish from the proposed capture activities. Thus, a discussion of these deaths to the sea turtle populations follows below.

Sea Turtle Expected Response to Capture

Actions that result in mortality affect listed species through the impact of the loss of individual animals and also through the loss of the reproductive potential of each animal to its respective population. Similarly, serious injuries to listed species due to an action that result in an animal's inability to reproduce affects a listed species due to the loss of that animal's reproductive potential. These effects have the potential to reduce the likelihood of survival and recovery of the species as a whole.

Sea turtle mortality as a result of the proposed activities affects listed species through the obvious impact of the loss of individual turtles and also through the loss of the reproductive potential of each turtle lost to the population. NRC (1990) estimates that the reproductive value of an adult loggerhead is 584 times that of an egg or hatchling, because so few eggs or hatchlings survive to maturity. Sea turtles are long-lived and some species delay sexual maturity for several decades. For example, loggerheads and green turtles may reach sexual maturity at 22 to 30 years of age, or 30 to 60 years of age, respectively. While exact numbers vary between species, all can lay hundreds of eggs every 2 to 4 years. Thus, the death of adult or juvenile females could potentially preclude the production of thousands of eggs and hatchlings, though most of these would not survive to sexual maturity. Mortality of males would preclude their contribution to future generations, though it is difficult to quantify this impact given the minimal data on male sea turtles.

Western Atlantic Loggerhead DPS Sea Turtles. It is possible that four sea turtles (either loggerhead, leatherback, green, hawksbill, or Kemp's ridley) could be incidentally captured. Therefore, NMFS would authorize the potential incidental take of up to 4 loggerheads, 1 of which is estimated to be a potential post-release mortality. The Turtle Expert Working Group has estimated that the total benthic loggerhead population in U.S. waters is over 200,000. However, this estimate has been called into question. The estimate is expected to be correct on the order of magnitude level, so a removal of 1 lethal take from this loggerhead population would represents approximately .0005%.

It is difficult to measure the effect that this removal percentage would have on the entire population. Since the northern subpopulation is the most vulnerable and represents only a small percentage, it is likely that the annual reproductive output from the northern subpopulation will produce individuals that would survive and replace the loss of 1 loggerhead. Therefore, the capture methodology as proposed is not likey to reduce the viability of this population as listed under the ESA. Thus, the activities from the proposed activities would not be expected to directly or indirectly reduce appreciably the likelihood of both the survival and recovery of the loggerhead sea turtle in the wild by reducing the reproduction, numbers, and distribution of this species.

Kemp's Ridley Sea Turtles. It is possible that four sea turtles (either loggerhead, leatherback, green, hawksbill, or Kemp's ridley) could be incidentally captured. Therefore, NMFS would authorize the potential incidental take of up to 4 Kemp's ridley turtles, 1 of which is estimated to be a potential post-release mortality. The total population of Kemp's ridleys is not known, but nesting has been increasing significantly in the past several years with a

favorable trajectory toward recovery goals. The rapid increase in nesting indicates that juvenile survivorship is high and is providing an increasing number of new recruits to the population. The additional anticipated lethal take of 1 Kemp's ridley sea turtle would not likely reverse the increases observed in the nesting population. Therefore, the capture methodology as proposed is not likey to reduce the viability of this population as listed under the ESA. Thus, the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both survival and recovery of the Kemp's ridley in the wild by reducing the reproduction, numbers, and distribution of the species.

Green Sea Turtles. It is possible that four sea turtles (either loggerhead, leatherback, green, hawksbill, or Kemp's ridley) could be incidentally captured. Therefore, NMFS would authorize the potential incidental take of up to 4 green sea turtles, 1 of which is estimated to be a potential post-release mortality. The total population of green sea turtles is not known, but nesting activity in Florida and the major Caribbean nesting beach at Tortuguero, Costa Rica, has increased over the long-term. At Tortuguero, Costa Rica, the estimated number of emergences was under 20,000 in 1971 and over 40,000 in 1996 with a high estimate of over 100,000 emergences in 1995 (Bjorndal *et al*. 1999). Significant increases in the populations of small juvenile green turtles have also been detected in Florida. A long-term in-water monitoring study in the Indian River Lagoon of Florida has tracked the population of juvenile green turtles in a foraging environment and noted significant increases in catch-per-unit effort (CPUE) (more than doubling) 1988-1990. A significant loss of juveniles over a long time span could have a time lag effect on the breeding population. The increased juveniles recorded in Florida may be the effect of some historical event and may not represent the current stresses to the population.

Based on increases in nesting activity and the increases in CPUE documented at limited in-water study sites, NMFS anticipates that the additional loss of 1 juvenile green sea turtle to the breeding population over the permit duration would not have a significant effect on the distribution and reproduction of the population. Therefore, the capture methodology as proposed is not likey to reduce the viability of this population as listed under the ESA. Thus, the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both the survival and recovery of the green sea turtle in the wild by reducing the reproduction, numbers, and distribution of the species.

Leatherback and Hawksbill Sea Turtles. It is possible that four sea turtles (either loggerhead, leatherback, green, hawksbill, or Kemp's ridley) could be incidentally captured. Therefore, NMFS would authorize the potential incidental take of potentially up to 4 leatherbacks or up to 4 hawksbills, 1 of which is estimated to be a potential post-release mortality. The determination of whether the loss of 1 leatherback will affect the breeding population is confounded by the fact that some nesting populations are increasing while the largest western Atlantic nesting assemblage in French Guiana-Suriname trans-boundary area is decreasing. The total Atlantic and Caribbean population size for hawksbills is not known. Of the 65 geopolitical units worldwide, where estimates of relative hawksbill nesting density exist, 38 of them have hawksbill populations that are suspected or known to be in decline and an additional 18 have experienced "well substantiated declines" (NMFS and USFWS 2007b). NMFS believes, however, the additional annual loss of 1 individual would not significantly affect the rate of recruitment to the breeding population of either species. Therefore, the capture

methodology as proposed is not likey to reduce the viability of these populations as listed under the ESA. Thus, the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both the survival and recovery of the leatherback and hawksbill sea turtles in the wild by reducing the reproduction, numbers, and distribution of these species.

VIII. Cumulative Effects

Cumulative effects include the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area considered by 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.

NMFS expects the natural and human-induced phenomena in the action area will continue to influence Atlantic sturgeon as described in the Environmental Baseline. However, it is the combination and extent to which these phenomena will affect Atlantic sturgeon that remains unknown.

Future federal actions as well as scientific studies contributing to conservation or recovery of Atlantic sturgeon will require consultation under the ESA and such studies are not included in the *Cumulative Effects* section of this Opinion. Sources queried for the information on non-federal activities include the U.S. Census Bureau and Lexis-Nexis news and law online search engine. On Nexis, we reviewed bills passed from 2008-2012 and pending bills under consideration were included as further evidence that actions are reasonably certain to occur. In addition, statutes already in place that continue to provide the authority of state agencies to regulate anthropogenic effects were reviewed. State regulation is critical for future anthropogenic impacts in a region. Pending and existing legislation for the states within the action area address water supply and water quality concerns; riparian and coastal development; ecosystem, natural resource, and endangered species recovery and protection; soil conservation; and regulation of fisheries and invasive species.

IX. Integration and Synthesis of Effects

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Brandon 1978, Mills and Beatty 1979, Stearns 1992, Anderson 2000). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment. For all research methods in this proposed action, we do not expect a reduction in fitness to individuals as long as NMFS protocols, permit conditions, and minimization measures are closely followed.

The narrative that follows integrates and synthesizes the information contained in the *Status of the Species*, the *Environmental Baseline*, and the *Effects of the Action* sections of this Opinion to assess the risk the proposed activities pose to Atlantic sturgeon. There are known cumulative

effects (i.e., from future state, local, tribal, or private actions) that fold into our risk assessment for this species.

The proposed issuance by PR1 of scientific research permits 16526, 16323, 16422, 16436, 16438, 16507, 16431, 16547, 16375, 16442, 16482, and 16508 would authorize directed take of Atlantic sturgeon in river systems across the U.S. range of the species, extending from the coastal waters of Maine to the tidal rivers of northern Florida. The proposed activities under this permit include: capture; handling; PIT, PSAT, and T-bar/Floy tagging; laparoscopy and boroscopy; gastric lavage; blood sampling; genetic tissue sampling; gonad biopsy; gill biopsy; fin ray sectioning; acoustic transmitter implantation and external acoustic transmitter attachment; anesthetization; hydroacoustic equipment; early life stage (ELS) sampling; and unintentional/incidental mortality.

The *Status of listed resources* section identified that past commercial fisheries and caviar markets led to diminished abundance of Atlantic sturgeon. Other threats to the survival and recovery of Atlantic sturgeon DPSs include land use, hydromodification projects, and mining. Reasonably likely future actions described in the *Cumulative effects* section include state legislation to address water supply and water quality concerns; riparian and coastal development; ecosystem, natural resource, and endangered species recovery and protection; soil conservation; and regulation of fisheries and invasive species.

Currently, there are no DPS population estimates for Atlantic sturgeon. The best estimates are for the Hudson (within New York Bight DPS) and Altamaha Rivers (within South Atlantic DPS). These estimates do not consider all life stages within those populations (i.e. spawning adult, non-spawning adult, sub-adult, juvenile). The Hudson River is believed to have the largest population in the New York Bight DPS, and is estimated to have 870 spawning adults per year (Kahnle *et al.* 2007). Relative abundance sampling reveal captures of 562 juveniles over two years (Sweka *et al.* 2006). The Altamaha River is believed to have the largest population in the South Atlantic DPS, and is estimated to have 343 spawning adults per year (Schueller and Peterson 2006). Estimates for juveniles in the Altamaha are 1,072 to 2,033 individuals (Schueller and Peterson 2010).

For all other areas, only qualitative information exisits. There are no population estimates for rivers in the Gulf of Maine DPS. However, we can look to qualitative information to provide river-specific information. Three hundred and thirty-six Atlantic sturgeon (nine adults and 327 sub-adults) were captured in the Kennebec River in a multi-filament gill net survey conducted intermittently from 1977-2000 (Squiers 2004). During this period, the CPUE of Atlantic sturgeon had increased by a factor of 10-25 (1977 – 1981 CPUE = 0.30 versus 1998 – 2000 CPUE = 7.43). An intensive gill net survey was conducted in the Merrimack River from 1987-1990 to determine annual movements, spawning, summering, and wintering areas of shortnose and Atlantic sturgeon (Kieffer and Kynard 1993). Thirty six Atlantic sturgeon were captured (70-156 cm total length). Most of these fish were under 100 cm total length, suggesting that these were all sub-adult sturgeon (Kieffer and Kynard 1993).

There are no population estimates for rivers in the Chesapeake Bay DPS. However, we can look to qualitative information to provide river-specific information. Within the Chesapeake Bay, the

U.S. Fish and Wildlife Service has been funding the Maryland Reward Program since 1996. This program has resulted in the documentation of approximately 1,700 Atlantic sturgeon. Five hundred sixty seven of these fish were hatchery fish, of which 462 were first time captures (14% recapture rate), and the remaining 1,133 were wild fish. Virginia also instituted an Atlantic sturgeon reward program in the Chesapeake Bay in 1997 and 1998 (ASSRT 2007). This reward program documented and measured 295 Atlantic sturgeon.

There are no population estimates for the Carolina DPS and any information on numbers is very sparse. A gill net survey for adult shortnose and juvenile Atlantic sturgeon was conducted in the Cape Fear River drainage from 1990-1992, and replicated 1997-2005. Each sampling period included two overnight sets (checked every 24 hrs). The 1990-1992 survey captured 100 Atlantic sturgeon below Lock and Dam #1 (rkm 95) for a CPUE of 0.11 fish/net-day. No sturgeon were collected during intensive sampling above Lock and Dam #1. In 1997, 16 Atlantic sturgeon were captured below Lock and Dam #1, an additional 60 Atlantic sturgeon were caught in the Brunswick (a tributary of the Cape Fear River), and 12 were caught in the Northeast Cape River (Moser *et al.* 1998). Relative abundance of Atlantic sturgeon below Lock and Dam #1 seemed to have increased dramatically since the survey was conducted in 1990-1992 (Moser *et al.* 1998) as the CPUE of Atlantic sturgeon was two to eight times greater during 1997 than in the earlier survey. An independent gill net survey, following the Albemarle Sound IGNS methodology, was initiated in 2001. Collections were low during the periods of 2001-2003, ranging from zero to one fish/yr. However, in 2004, this survey collected 14 Atlantic sturgeon ranging from 460 to 802 mm FL, and averaging 575 mm FL. During the same time period (2002 – 2003), four Atlantic sturgeon (561 – 992 mm FL) were captured by NCSU personnel sampling in the Neuse River (Oakley 2003). Similarly, the NCDMF Observer Program documented the capture of 12 Atlantic sturgeon in the Pamlico Sound from April 2004 to December 2005; none of these were YOY or spawning adults, averaging approximately 600 mm TL (Blake Price, NCDMF, Pers. Comm. 2006).

Permit amendments 16526, 16323, 16422, 16436, 16438, 16507, 16431, 16547, 16375, 16442, 16482, and 16508 would be valid for five years until their expiration and would authorize non-lethal sampling methods on up to 1,033-1,036 Gulf of Maine DPS Atlantic sturgeon annually; 2,243-2,277 year 1, 2,268-2,302 year 2 and year 3, and 3,218-3,252 year 4 and year 5 New York Bight DPS Atlantic sturgeon annually; 633-640 Chesapeake Bay Atlantic sturgeon annually, 410-414 Carolina DPS Atlantic sturgeon annually, and 4,181-4,332 South Atlantic DPS Atlantic sturgeon annually. All captured Atlantic sturgeon would be captured, handled, weighed, measured, PIT tagged, Floy tagged, and genetic tissue sampled. Smaller subsets of these fish would undergo any combination of the other proposed activities.

Although some degree of stress or pain is likely for individual fish captured, and while some other sampling methods will result in tissue injuries, none of the research procedures are expected to result in mortality or reduced fitness of individuals. Delayed or aborted spawning for some individual fish is a possibility, but the likelihood is remote given the mitigation measures proposed. The proposed permit is not expected to affect these population's reproduction, distribution, or numbers. Because the proposed action is not likely to reduce the these population's likelihood of surviving and recovering in the wild, it is not likely to reduce the DPSs' likelihood of surviving and recovering in the wild.

IX. Conclusion

After reviewing the current status of threatened Gulf of Maine DPS Atlantic sturgeon, endangered New York Bight DPS Atlantic sturgeon; Endangered Chesapeake Bay Atlantic sturgeon, Carolina Atlantic sturgeon, and South Atlantic Atlantic sturgeon; endangered shortnose sturgeon; endangered leatherback, green, hawksbill, loggerhead, and Kemp's ridlay turtles; the environmental baseline for the action area; the effects of the proposed research programs, and the cumulative effects; it is NMFS's biological opinion that the issuance of permits 16526, 16323, 16422, 16436, 16438, 16507, 16431, 16547, 16375, 16442, 16482, and 16508 is not likely to jeopardize the continued existence of these listed species and DPSs. Critical habitat has not been designated for Atlantic or shortnose sturgeon and critical habitat designated for sea turtles is not within the action area.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. 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 the USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the USFWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, 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. 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 taking under the Act 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 PR1 so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. PR1 has a continuing duty to regulate the activity covered by this incidental take statement. If PR1 1) fails to assume and implement the terms and conditions or 2) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the applicant must report progress of the action and its impact on the species to NMFS as specified in the incidental take statement [50 CFR 402.14(i)(3)].

Amount or Extent of Take

Despite mitigation measures aimed at reducing the negative impacts of this project to shortnose sturgeon and green, leatherback, loggerhead, Kemp's ridley, and hawksbill sea turtles, NMFS anticipates that the proposed action could potentially result in incidental take of these listed species. Five shortnose sturgeon and four sea turtles (either loggerhead, green, leatherback, Kemp's ridley or hawksbill) are permitted to be captured during the five years of this research

(see Tables 48-50). No lethal take of any shortnose sturgeon or sea turtles referenced above is authorized during this project. Those would be the thresholds for reinitiating consultation. Should any of these limits be exceeded during project activities, the reinitiation provisions of this Opinion apply.

Table 48. Authorized annual Incidental Take for sea turtles and shortnose sturgeon - Permit Number 16547.

Species	Life Stage	Sex	Number of Takes	Take Action	Location	Dates/ Time Period
Loggerhead sea turtle (*Caretta caretta*) Green sea turtle (*Chelonia mydas*) Leatherback sea turtle (*Dermochelys coriacea* Hawksbill sea turtle (*Eretmochelys imbricata*) Kemp's ridley sea turtle (*Lepidochelys kempii*)	Juvenile sub-adult or adult	M/F	2	Incidental Take by gillnet or trawl	Chesapeake Bay coastal areas	Year-round
Shortnose sturgeon (*Acipenser brevirostrum*)	Juvenile or Adult	M/F	4	Incidental Take by gill net or trawl	Chesapeake Bay & tributaries including all fresh an saline riverine and coastal areas	Year- round

Table 49. Authorized annual Incidental Take for sea turtles - Permit Number 16482.

Species	Life Stage	Sex	Number of Takes	Take Action	Location	Dates/Time Period
Loggerhead sea turtle (*Caretta caretta*) Green sea turtle (*Chelonia mydas*) Leatherback sea turtle (*Dermochelys coriacea* Hawksbill sea turtle (*Eretmochelys imbricata*) Kemp's ridley sea turtle (*Lepidochelys kempii*)	Juvenile sub-adult or adult	M/F	2	Incidental Take by drift net or gillnet, or trawl	Georgia-Florida coastal areas when gill netting or drift netting	Year-round

Table 50. Authorized annual Incidental Take for shortnose sturgeon - Permit Number 16508.						
Species	**Life Stage**	**Sex**	**Number of Takes**	**Take Action**	**Location**	**Dates/Time Period**
Shortnose Sturgeon	Juvenile or Adult	M / F	1	Incidental Take by gillnet	St Marys,, Nassau, or St Johns River	Year-round

Reasonable and Prudent Measures

Reasonable and prudent measures (RPMs) are non-discretionary measures to avoid or minimize take that must be carried out by cooperators for the exemption in section 7(o)(2) to apply. PR1 has the continuing duty to regulate the activities covered in this incidental take statement where discretionary Federal involvement or control over the action has been retained or is authorized by law. The protective coverage of section 7(o)(2) may lapse if PR1 fails to exercise its discretion to require adherence to terms and conditions of the incidental take statement, or to exercise that discretion as necessary to retain the oversight to ensure compliance with these terms and conditions. Similarly, if any applicant fails to act in accordance with the terms and conditions of the incidental take statement, protective coverage may lapse.

PR5 believes that full application of the project design and mitigation measures included as part of the proposed action, together with use of the RPMs and terms and conditions described below, are necessary and appropriate to minimize the likelihood of incidental take of shortnose sturgeon and listed sea turtles due to completion of the proposed action.

The applicant shall:

1. Ensure completion of a monitoring and reporting program to confirm this Opinion is meeting its objective of limiting the extent of take and minimizing take from permitted activities.

2. Minimize the impact of incidental take resulting from capturing shortnose sturgeon and loggerhead, leatherback, hawksbill, green, or Kemp's ridley sea turtles.

Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, PR1 and the applicant must comply with the following terms and conditions, that implement the RPMs described above. Partial compliance with these terms and conditions may invalidate this take exemption, result in more take than anticipated, and lead PR5 to a different conclusion regarding whether the proposed action will result in jeopardy or the destruction or adverse modification of critical habitat.

Shortnose sturgeon (all permits):

-The applicants must monitor gear closely. If a shortnose sturgeon were captured in efforts targeting Atlantic sturgeon, the same standard conditions in permits used for ensuring survival of both species is required (Kahn and Mohead 2010).
-Permit holders must suspend all permitted activities in event the incidental takes are exceeded or if a serious injury or mortality occurrs. The permit holder is then required to report the incident to PR1 within two business days and also submit a written incident report. PR1 would then either allow permitted activities to resume with modifications, or revoke the permit based on review of the incident report and in consideration of the Terms and Conditions of the permit.

Sea turtles (all permits):

-In all boating and research activities within the study area, a close watch must be made for sea turtles to avoid interaction and harassment.
-Researchers netting in coastal waters must attempt to avoid sea turtle interactions by sampling in waters below 18°C, when turtles are typically absent.
-Vessels must only travel between 0-5 knots while engaged in acoustic monitoring to avoid posing a vessel strike risk to sea turtles or marine mammals.
- Sea turtles must be removed from nets immediately and released. In addition, capture gear shall not be placed in the water, or will be removed, if any of these animals are known to be present in the immediate area.
-Interactions with sea turtles must be documented including any pertinent detail (species, type of interaction, location, date, size, water and air temperature, any obvious patterns and photos, where possible).
-If a sea turtle is incidentally captured during netting, the Permit Holder, Principal Investigator, Co-investigator(s), or Research Assistant(s) acting on the Permit Holder's behalf must use care when handling a live turtle to minimize any possible injury; and appropriate resuscitation techniques must be used on any comatose turtle prior to returning it to the water. All sea turtles must be handled according to procedures specified in 50 CFR 223.206(d)(1)(i).
-In the event a captured sea turtle dies, or is severely injured, all permitted activities must cease and researchers must contact the appropriate NOAA Regional or State marine mammal and/or sea turtle stranding networks, as well as the Chief, Permits Division and/or the permit analyst at (301) 427-8401.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities 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 conservation recommendations would provide information that would improve the level of protections afforded in future consultations involving proposals to issue permits for research on the endangered Atlantic sturgeon:

1. *Take Allocations.* Since Atlantic sturgeon DPSs were recently listed, there are no standardized past catch reports to examine and estimate how many takes will occur per unit effort. Before authorizing any additional permits for activities similar to those contained in the proposed permits, PR1 should require bi-annual progress reports. This frequent progress reporting can gauge whether researchers' actual take is matching up with their anticipated/authorized take. If actual take is lower than anticipated/authorized take, an amendment to the respective permit could be done to lower annual take for that respective permit.

REINITIATION NOTICE

This concludes formal consultation on the 12 proposed Atlantic sturgeon permits pursuant to the provisions of section 10 of the Endangered Species Act. 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 allowable take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the identified 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.

APPENDIX

Maps of Action Areas

<u>Permit 16526: Atlantic sturgeon in the Gulf of Maine</u>

Figure 1: Proposed Action Area for File No. 16526. Sampling would occur in the Penobscot, Kennebec, and Saco Rivers in Maine.

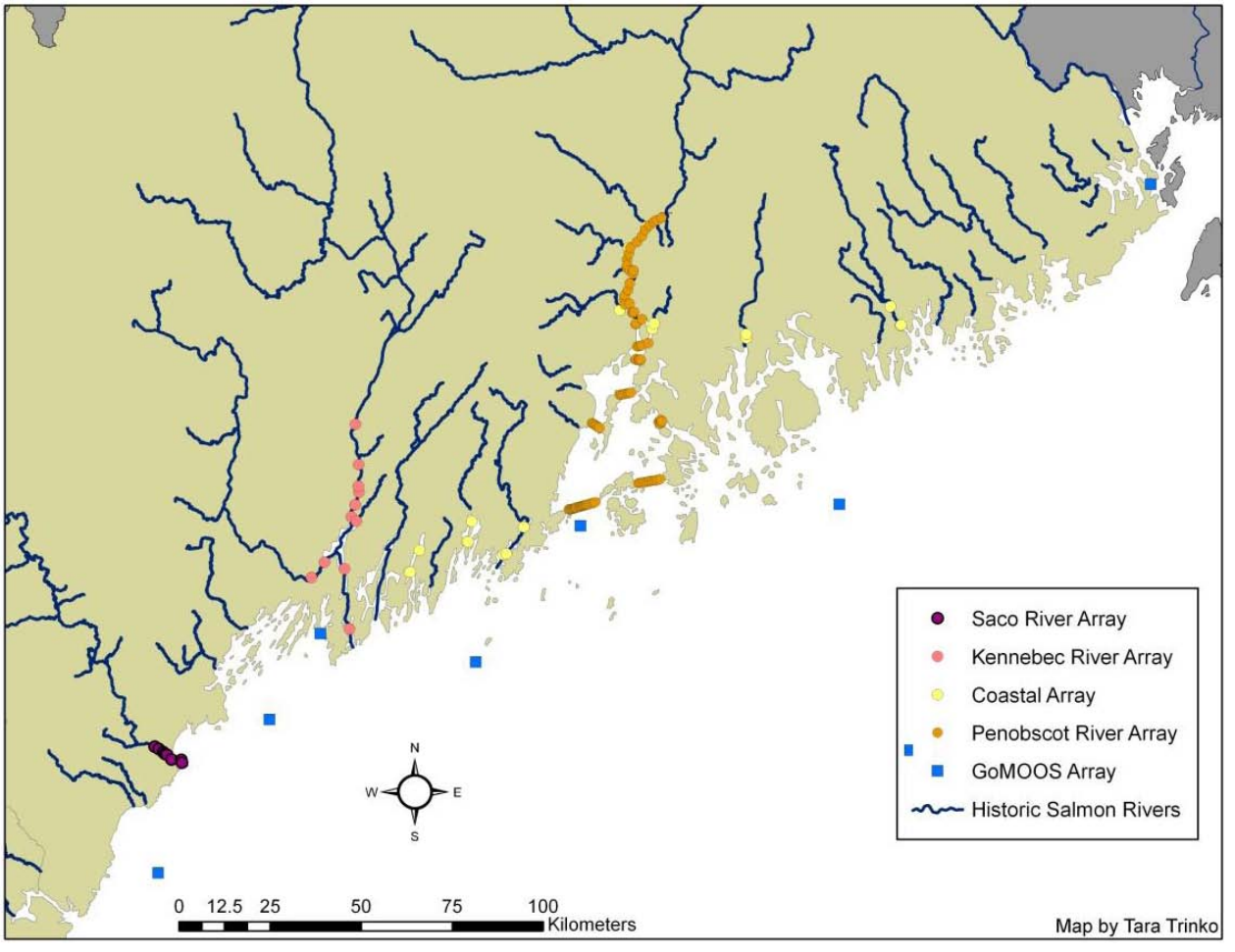


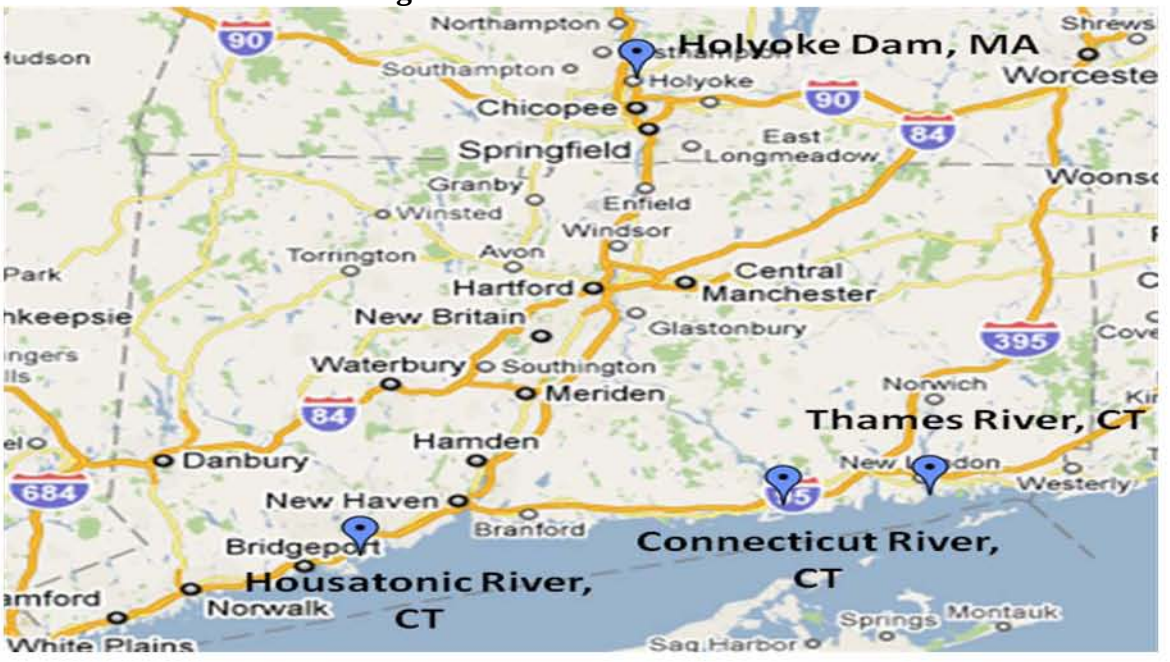
Figure 2: Proposed Action Area for Permit 16526. Sampling would occur in the Merrimack River, and coastal waters coastal waters off Massachusetts and New Hampshire.

Table 1: Proposed Action Area for File No. 16526. Small coastal rivers and water bodies of ME, NH, and MA where Atlantic sturgeon sampling may occur.

Waterbody	State
St. Croix River	ME
Dennys River	ME
Narraguagus River	ME
Union River	ME
Passagassawakeag River	ME
St. George River	ME
Medomak River	ME
Damariscotta River	ME
Sheepscot River	ME
Androscoggin River	ME
Royal River	ME
Presumpscot River and inshore Casco Bay	ME
Scarborough River	ME
Mousam River	ME
Webhannet River	ME
York River	ME
Piscataqua River	ME, NH
Merrimack River and coastal areas	MA

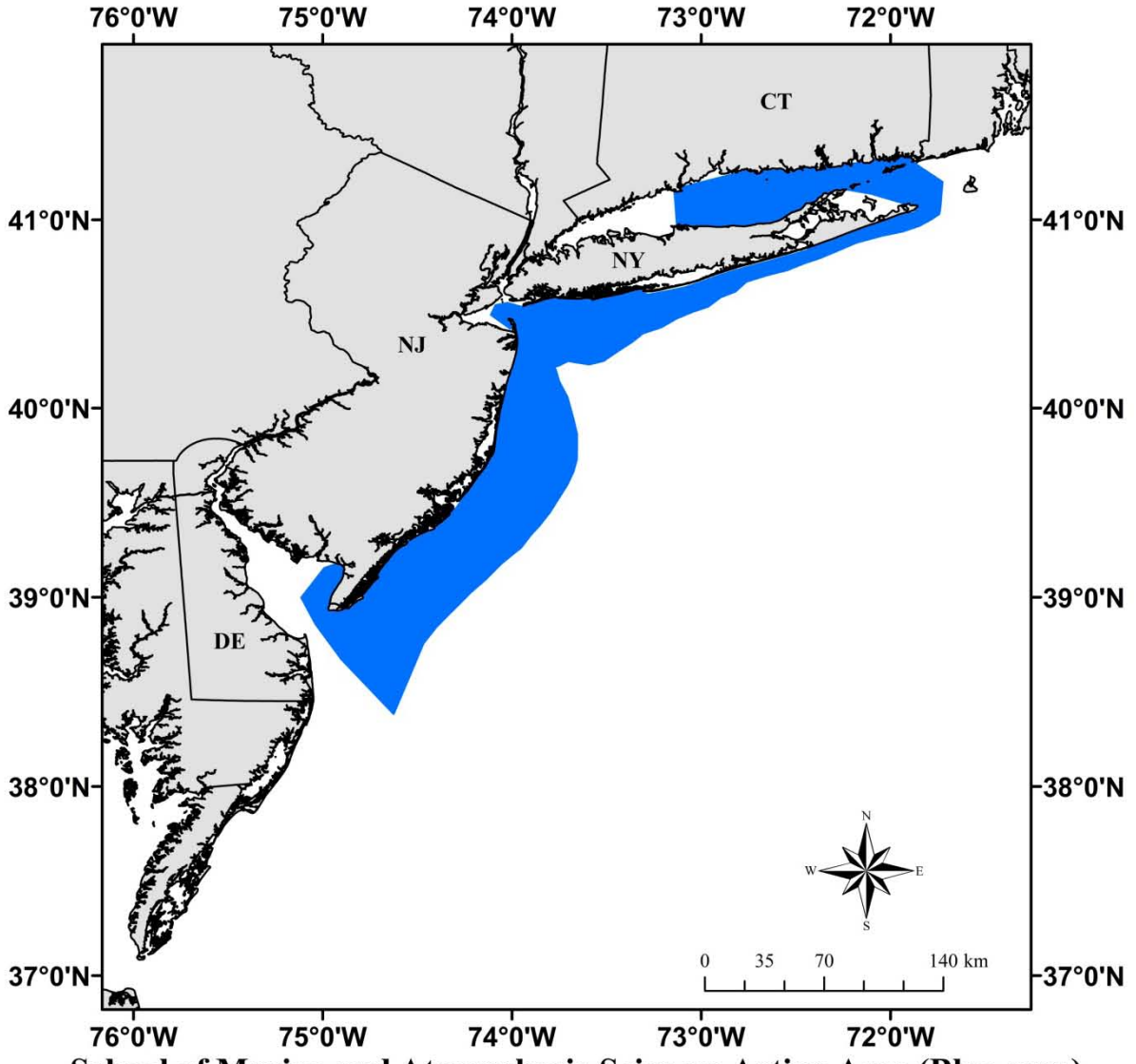
Permit 16323: Atlantic sturgeon research in Connecticut waters and Long Island Sound

Figure 3: Proposed Action Area for File No. 16323. Sampling would occur in coastal rivers (i.e., the Connecticut, Thames, and Housatonic Rivers), and the corresponding Bays of Connecticut waters in Long Island Sound.



Permit 16422: Determining the connectivity among and fine-scale habitat-use within Atlantic sturgeon aggregation areas in the New York Bight

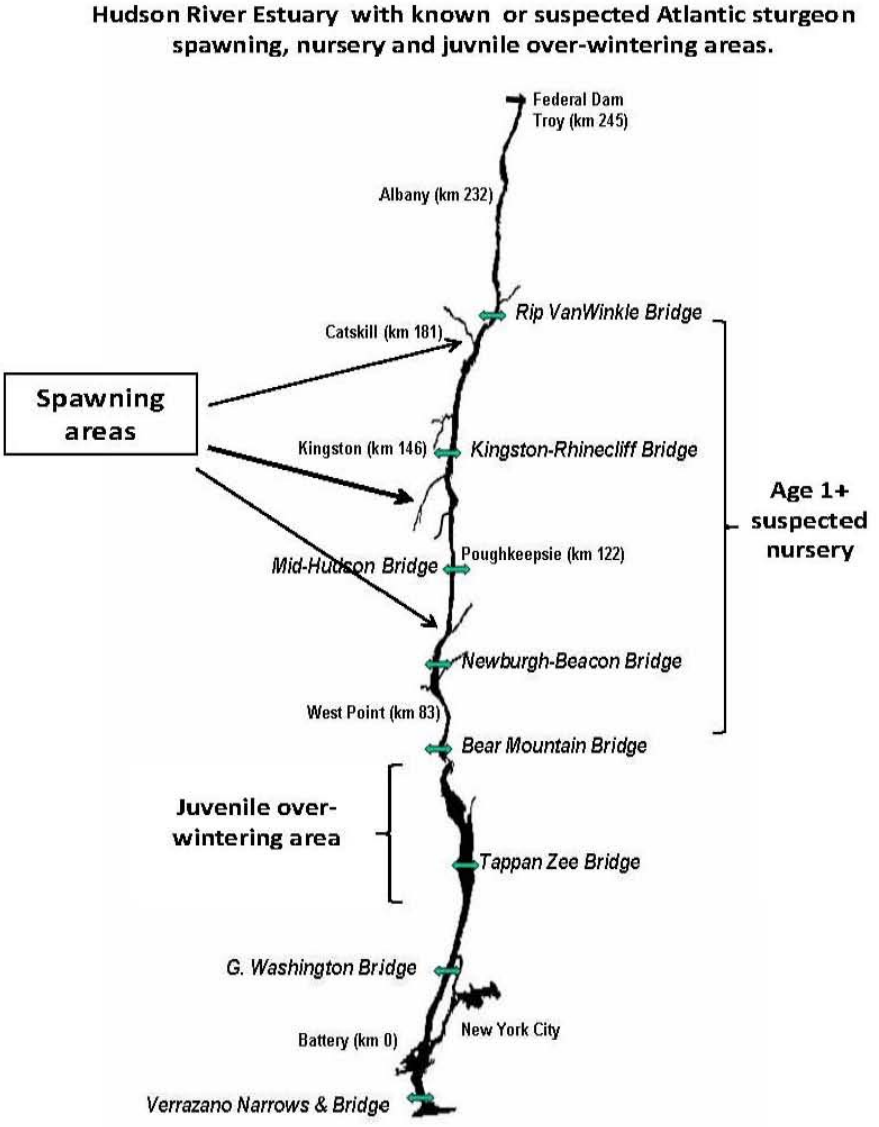
Figure 4: Proposed Action Area for File No. 16422. Sampling would take place in the marine and estuarine waters of Connecticut, New York, New Jersey, and Delaware, including the Atlantic Ocean and Long Island Sound.



School of Marine and Atmospheric Sciences Action Area (Blue area)

Permit 16436: Research and monitoring of Atlantic sturgeon in the Hudson River estuary

Figure 5: Proposed Action Area for File No. 16436. Sampling would take place in the Hudson River and estuary, primarily from river kilometer 25 to river kilometer to 115.



Permit 16438: Scientific research on Atlantic sturgeon in the Delaware River and Bay

Figure 6: Proposed Action Area for File No. 16438. Sampling would take place mainly from Artificial Island (river kilometer 79) to Trenton, NJ (rkm 215); tracking could occur from the mouth of Delaware Bay (rkm 0) to Trenton.

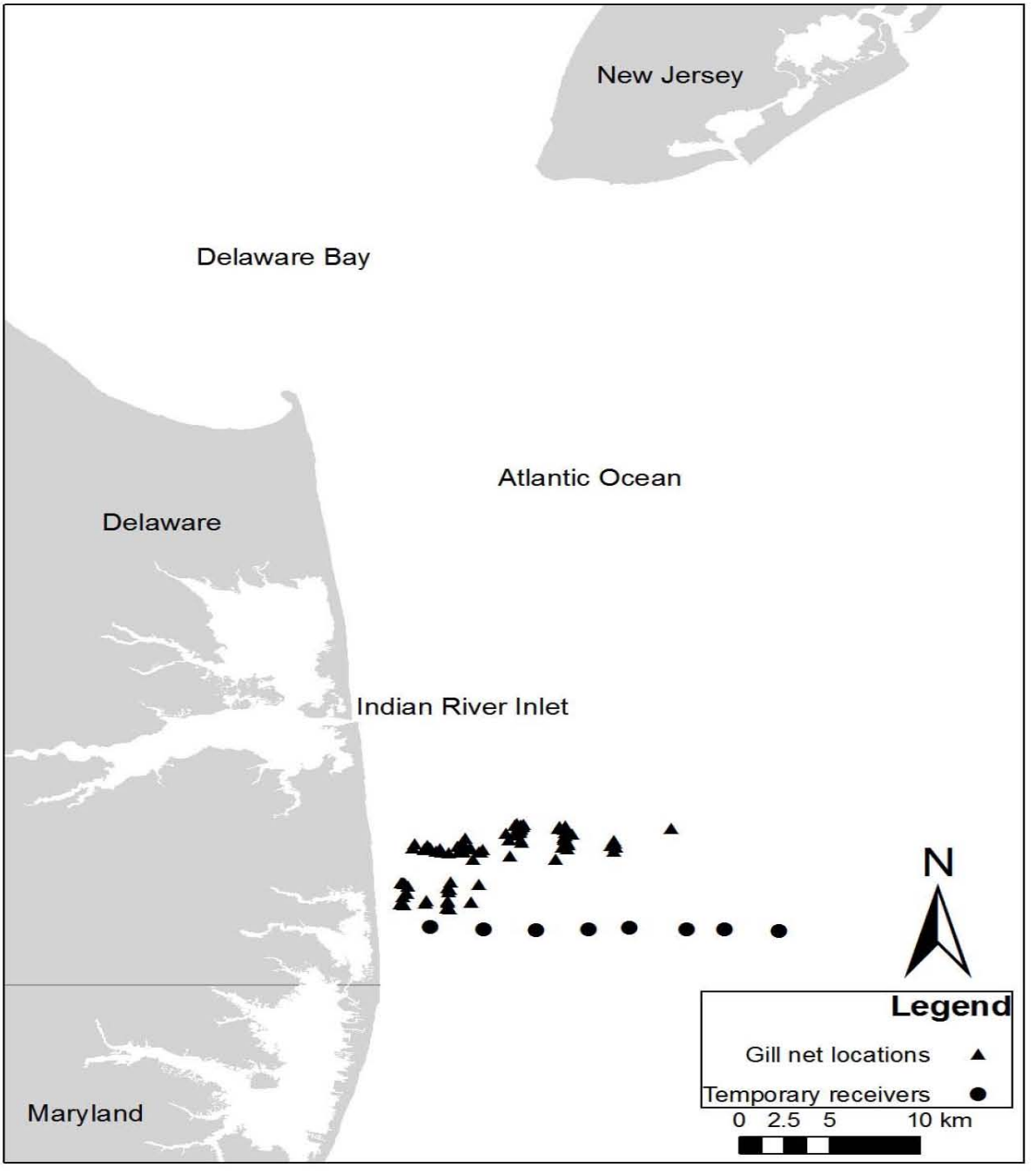
Permit 16431: Delaware Division of Fish and Wildlife juvenile Atlantic sturgeon survey

Figure 7: Proposed Action Area for File No. 16431. Sampling would take place between Cherry Island Flats and Marcus Hook (rkm 119-122).

Potential sampling sites, denoted by yellow boxes, of the juvenile shortnose sturgeon telemetry study on the Delaware River conducted by DE DFW personnel. Telemetry array coverage of DE DFW, Environmental Research Consultants Inc, and Delaware State University VEMCO VR-2 receivers (denoted by red cots) (map courtesy of Jared Jacobini, DE DFW).

Permit 16507: Sturgeons in the mid-Atlantic; identification of critical habitats, population assessment and migratory patterns

Figure 8: Proposed Action Area for File No. 16507. Sampling would occur in the upper freshwater portions of the Delaware River (approx. rkm 215) and in the near shore Atlantic Ocean off the coast of Delaware.



Permit 16547: Atlantic sturgeon research in the Chesapeake Bay

Figure 9: Proposed Action Area for File No. 16547. Sampling would occur in the Chesapeake Bay, the James, York, Rappahannock, Potomac, and Choptank Rivers, and other tidal tributaries.

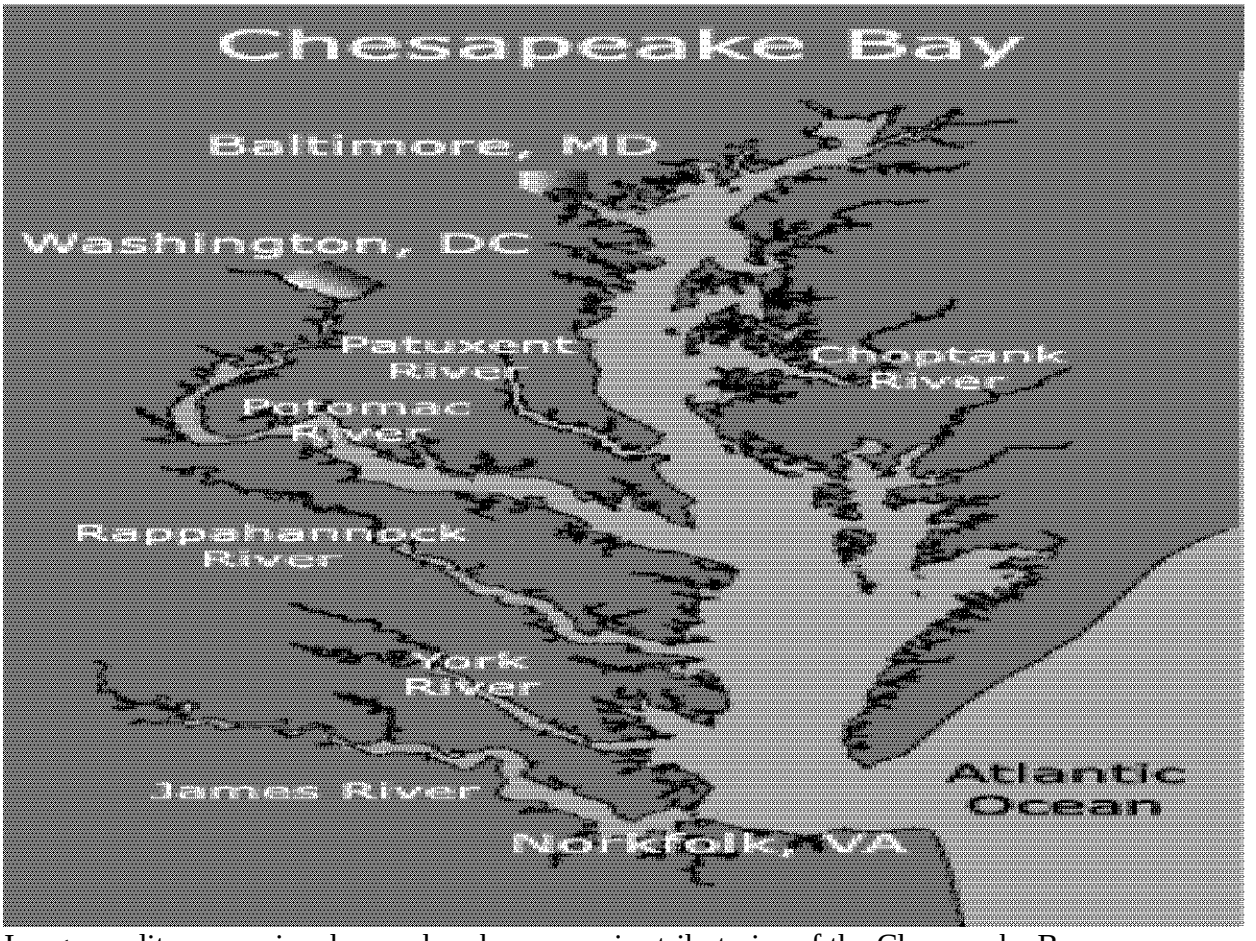
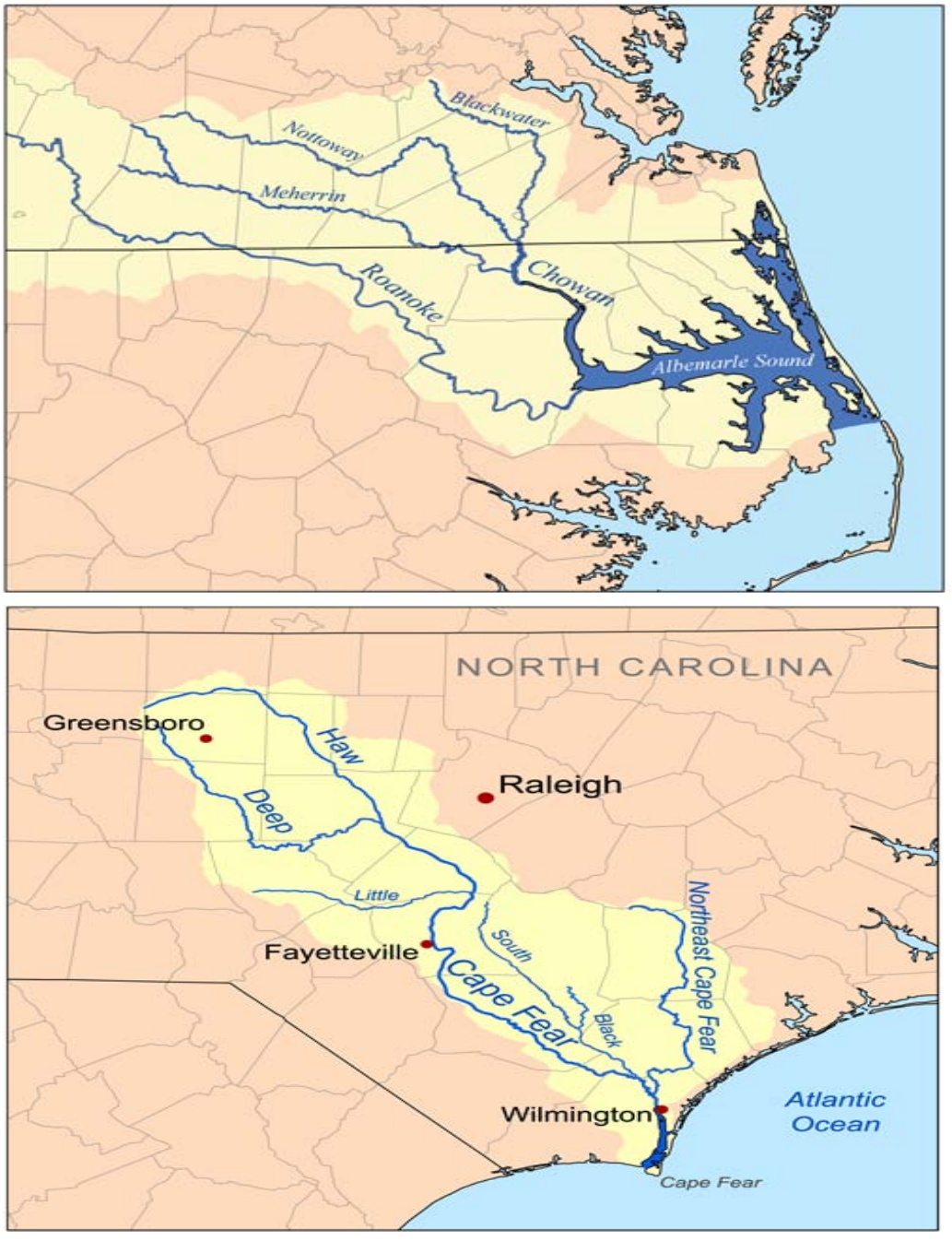


Image credit: www.pippahunnechurch.com, major tributaries of the Chesapeake Bay

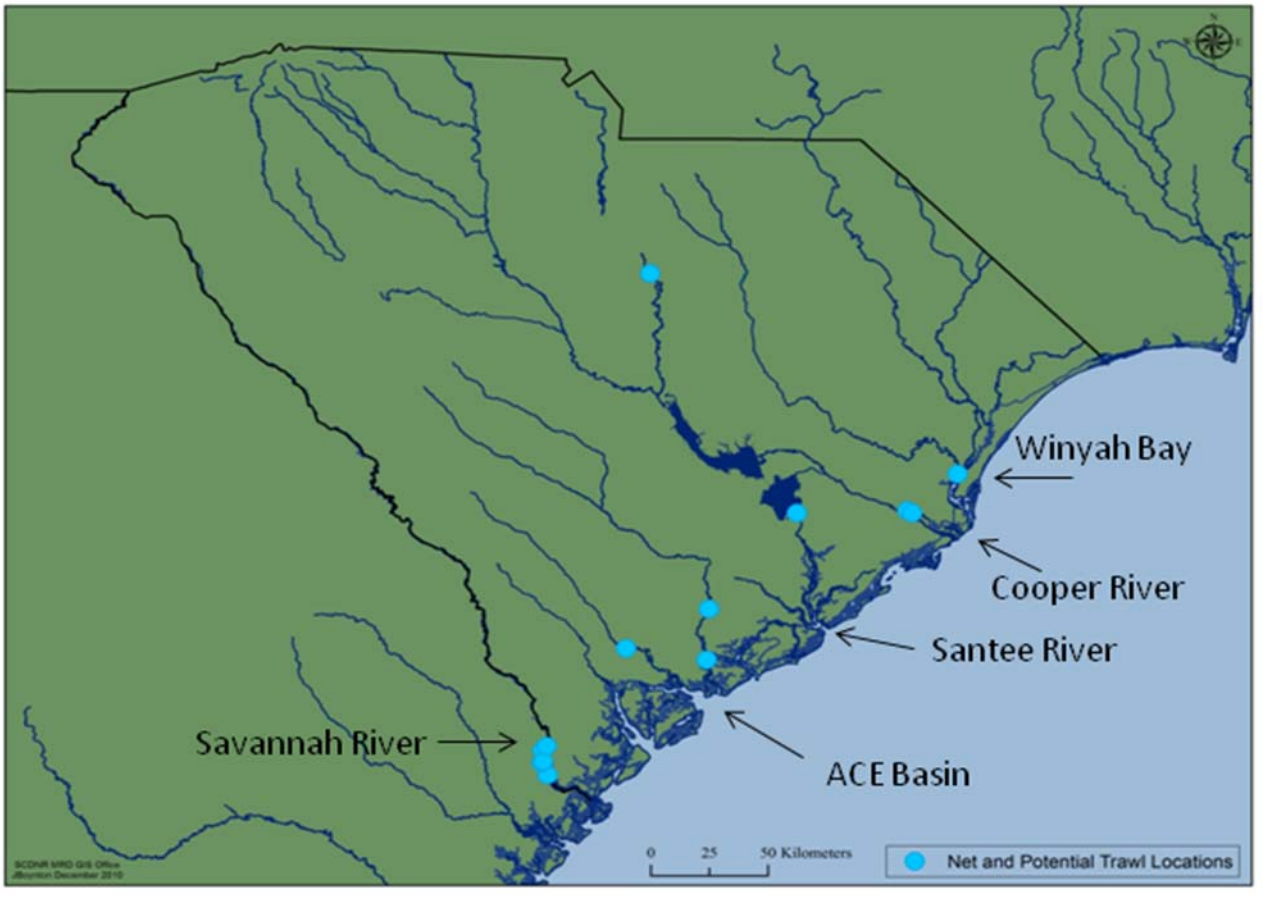
Permit 16375: Presence, abundance, and distribution of Atlantic sturgeon in North Carolina rivers and estuaries

Figure 10: Proposed Action Area for File No. 16375. Sampling would occur in parts of Albermarle Sound (including the Chowan and Roanoke Rivers and their tributaries) and the Cape Fear River basin (from Wilmington to rkm 97, including associated tributaries). (See also: http://maps.google.com/maps/ms?ie=UTF8&hl=en&oe=UTF8&msa=0&msid=110136104058063386946.00048164b43be6240e008)



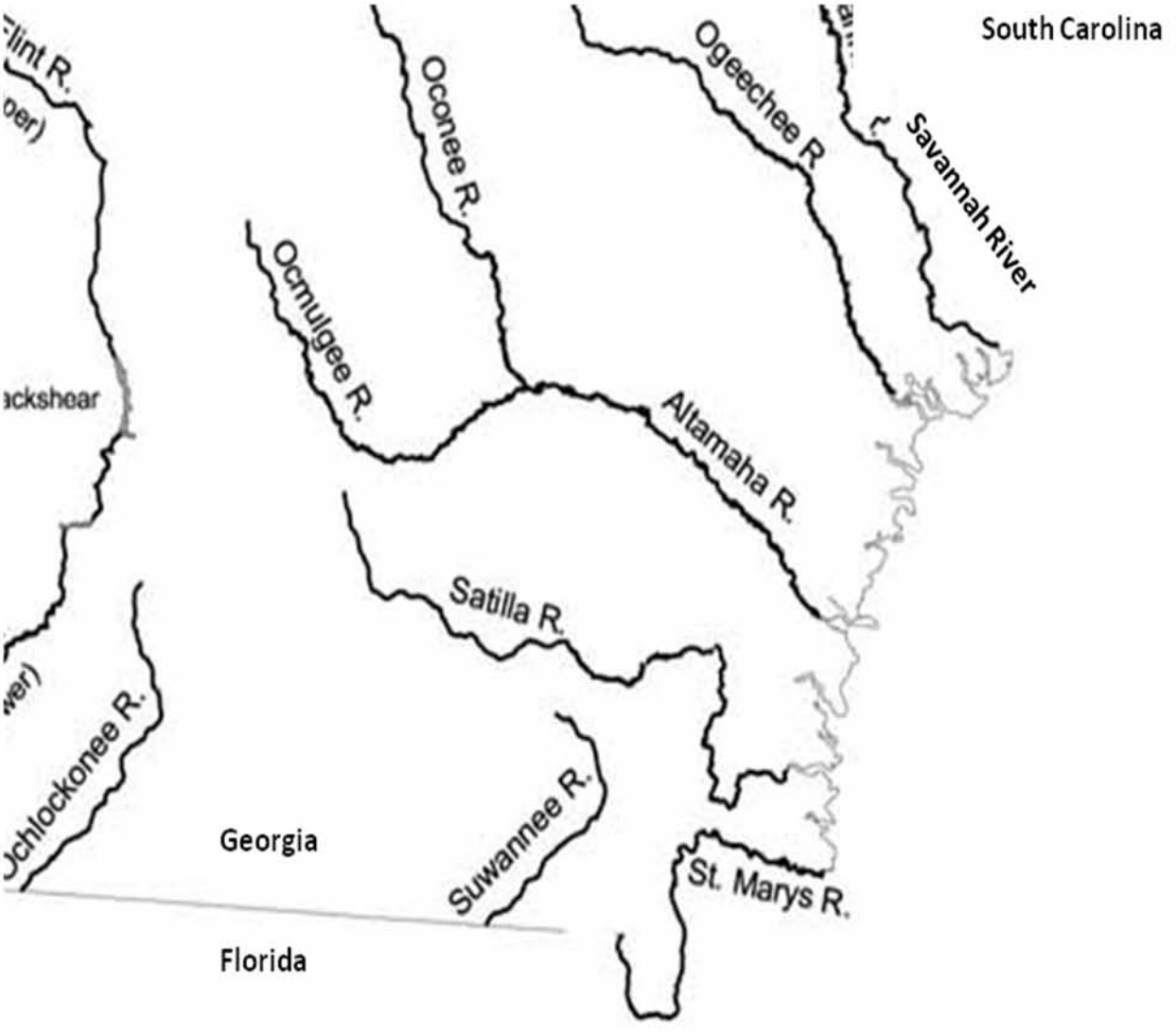
Permit 16442: Atlantic sturgeon scientific research in South Carolina rivers

Figure 11: Proposed Action Area for File No. 16442. Sampling would occur in the Santee-Cooper watershed (specifically the Santee and Cooper Rivers) and the Winyah Bay watershed (primarily the Great Pee Dee River, but also its tributaries: the Black, Waccamaw, Little Pee Dee, and Lynches rivers). Sampling would also occur in the Savannah River and the Ashepoo, Combahee, and Edisto rivers (collectively known as the ACE Basin watershed). (See also: http://maps.google.com/maps/ms?ie=UTF8&hl=en&msa=0&msid=113286167511014551758.00048f4724bacf8629924&ll=32.852678,-80.19702&spn=1.68432,2.469177&t=h&z=9



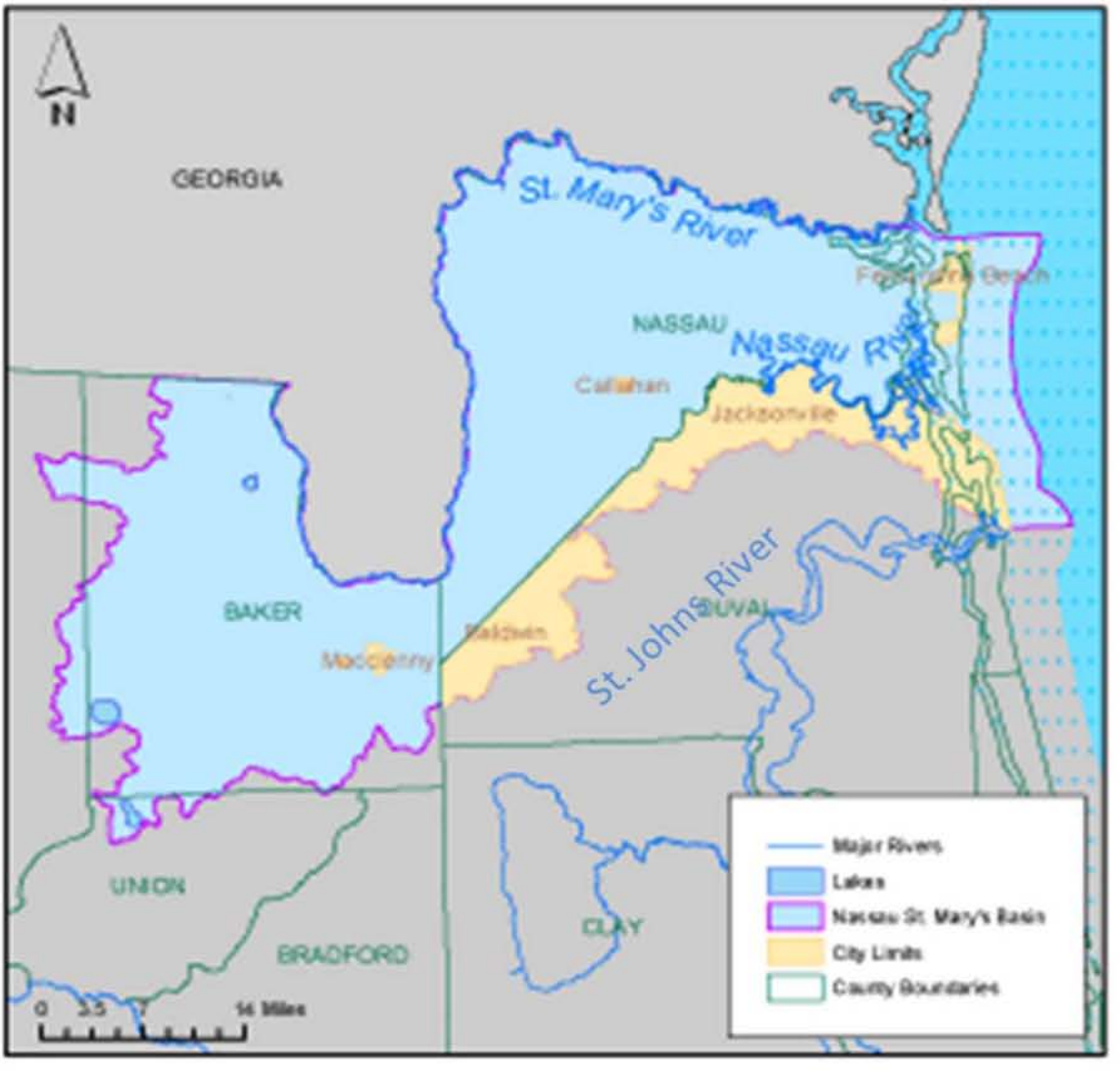
Permit 16482: Population dynamics and seasonal habitat use of Atlantic sturgeon in Georgia

Figure 12: Proposed Action Area for File No. 16482. Sampling would occur in the Savannah, Ogeechee, Altamaha, Satilla and St. Marys Rivers. (See also: http://maps.google.com/maps/ms?msid=201813649479523504220.0004aae071af72e848a5e&msa=0



Permit 16508: Identification and tracking of Acipenser oxyrinchus populations in the St. Marys, Nassau, and St. Johns Rivers, Florida and Georgia

Figure 13: Proposed Action Area for File No. 16508. Sampling would occur in the St. Marys, Nassau, and St. Johns Rivers, Florida.



Map: FL DEP

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