NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION

Action Agency:	Permits and Conservation Division of the Office of Protected Resources, National Oceanic and Atmospheric Administration's National Marine Fisheries Service
Activity Considered:	Issuance of two scientific permits: Permit No. 19331 to Harold Brundage of Environmental Research and Consulting, Inc., for research on Atlantic and shortnose sturgeon in the Delaware River; and Permit No. 19642 to Jason Kahn for research on Atlantic and shortnose sturgeon in the in the York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast pursuant to section 10 (a)(1)(A) of the Endangered Species Act of 1973.
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service
Approved:	Donna S Wieting Donna S. Wieting Director, Office of Protected Resources
Date:	JUN 24 2016
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1 INTRODUCTION

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to consult with the United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions would affect listed species and their critical habitat. If an incidental take is expected, section 7(b)(4) requires the consulting agency to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with NMFS or the USFWS, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the USFWS concurs with that conclusion (50 CFR §402.14(b)).

For the actions described in this document, the action agency is the National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division.

The biological opinion (opinion) and incidental take statement portions of this consultation were prepared by NMFS Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402. This document represents NMFS' final opinion on the effects of these actions on endangered and threatened species and critical habitat that has been designated for those species.

NMFS completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document would be available through NMFS' Public Consultation Tracking System (PCTS) at https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts.

1.1 Background

The NMFS ESA Interagency Cooperation Division frequently consults with the NMFS Permits and Conservation Division on the issuance of scientific research permits on ESA-listed species pursuant to Section 10(a)(1)(A) of the ESA. In some cases where multiple actions are sufficiently alike—occurring in similar action areas, targeting the same species, using identical research techniques—the ESA Interagency Cooperation Division will consider the issuance of multiple permits in a batched consultation. This is to improve efficiency and ensure proper consideration of cumulative effects.

In its initiation package, the NMFS Permits and Conservation Division presented two proposed scientific research permits (Nos. 19331 and 19642) authorizing directed take of Atlantic and shortnose sturgeon. Once effective, Permit No. 19331 would renew and combine similar research authorized in the Delaware River and Estuary by existing Permits No. 14604 for shortnose sturgeon and No. 16438 for Atlantic sturgeon. Permit No. 19642 would renew Permit No. 16547-01 for shortnose and Atlantic sturgeon research in the York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast. If issued, these permits would be valid for five years from the date of issuance, with Harold Brundage (No. 19331) and Jason Kahn (No. 19642) as Principal Investigators (PI). Both proposed actions will use similar capture techniques and research procedures targeting Atlantic and shortnose sturgeon at all life stages.

Due to the similarities of the proposed actions, the ESA Interagency Cooperation Division is considering the effects of the issuance of Permit Nos. 19331 and 19642 in this batched consultation.

1.2 Consultation History

On February 4, 2016, the National Oceanic and Atmospheric Administration (NOAA)'s NMFS, Office of Protected Resources, Permits and Conservation Division (Permits Division) sent application materials to NMFS, Office of Protected Resources, ESA Interagency Cooperation Division on a proposal to issue two permits for research: 1) Permit No. 19331 to conduct scientific research activities on shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*) in the Delaware River and Estuary, and 2) Permit No. 19642 to conduct scientific research activities on shortnose sturgeon and Atlantic sturgeon in the in the York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast.

On February 10, the ESA Interagency Cooperation Division requested and received digital documents of the application materials from the Permits Division.

From February 17 through February 29, 2016, the ESA Interagency Cooperation Division communicated with the Permits Division regarding research methodology, take, and permit deadlines.

On February 22, 2016, the Permits Division sent a revised draft permit to the ESA Interagency Cooperation Division.

On February 29, 2016, the ESA Interagency Cooperation Division deemed the application complete and initiated formal consultation with the Permits Division.

2 DESCRIPTION OF THE PROPOSED ACTION

The Permits Division proposes to issue two permits: (1) Permit No. 19331 to Harold Brundage of Environmental Research and Consulting (ERC), Inc., to study Atlantic and shortnose sturgeon in the Delaware River; and (2) Permit No. 19642 to Jason Kahn to study Atlantic and shortnose sturgeon in the in the York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast for scientific research pursuant to section l0 (a)(1)(A) of the ESA. The proposed activities involve purposeful harassment, harm, wounding, trapping, capture, or collection ("take[1]") of the endangered shortnose sturgeon and Atlantic sturgeon for scientific purposes.

2.1 Proposed Activities under Permit No. 19331

The activities proposed under Permit No. 19331 are to locate and document Atlantic and shortnose sturgeon habitat use in the lower non-tidal Delaware River (between river kilometer (rkm) 0 to 245), characterizing the relative abundance, recruitment, spatio-temporal distributions, and reproduction, as well as assessing the potential for entrainment and impingement of various life stages of Atlantic and shortnose sturgeon at the intakes of selected industrial sites on the Delaware River. The permit would be valid for five years from the date of issuance and would authorize the following proposed methodology for the "take" (Table 1) of Atlantic and shortnose sturgeon in the Delaware River and Estuary by Harold Brundage and ERC, Inc. researchers. The requested take of shortnose and Atlantic sturgeon is based on prior Delaware River sampling conducted since 1999 through today for shortnose sturgeon and since 2005 through present for Atlantic sturgeon, and on research objectives of ERC, Inc. over the next five years.

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[1] The ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The term "harm" is further defined by regulations (50 CFR §222.102) as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering."

Table 1. Proposed "takes" of ESA-listed sturgeon during H. Brundage's (ERC, Inc.) research activities in the Delaware River and Estuary, Permit No. 19331. Both male and female animals are represented in the table.

Species	Listing Unit or Stock	Life Stage	Expected Take	Take Action	Observe/ Collect Method	Procedure	Details
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/ Sub-adult/ Juvenile	420	Capture/Handle/ Release	Net, Gill	Capture/recapture; Mark, Floy T-bar; Mark, Passive Integrated Transponder (PIT) tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video	**Capture/recapture population estimate** up to 420 adult or subadult animals (≥500 mm total length) and juveniles (<500 mm total length) per year. Collection may also include gill/ trammel nets; traps; trawls; & seines. *Each captured individual may be recaptured up to two times daily. Once this limit is reached, nets will be pulled from the water for the day.
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/ Sub-adult	30	Capture/Handle/ Release	Net, Gill	Anesthetize; Instrument, internal (e.g., VHF, sonic); Mark, Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video	**Capture and acoustic tagging** up to 30 adult or subadult animals (≥500 mm total length) per year. Collection may also include gill/trammel nets; traps; trawls; & seines. **Note**: sub-adults = (500 to < 600 mm total length)
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Juvenile	30	Capture/Handle/ Release	Net, Gill	Anesthetize; Instrument, internal (e.g.,VHF, sonic); Mark, Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video	**Capture and acoustic tagging** up to 30 juveniles (300 to <500 mm total length) per year; Would not sonic tag animals less than 300 mm or if the tag exceeds 2% of body weight. Collection may also include gill/ trammel nets; traps; trawls; & seines.
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/ Sub-adult	20	Capture/Handle/ Release	Net, Gill	Mark, Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video & Other	**Capture** up to 20 adults/sub-adults (≥500 mm total length) per year, and tethered in a **nylon sock and remotely sensed with hydro-acoustic equipment** prior to release.
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Egg/ Larvae	500	Intentional (Directed) Mortality	Net, D-frame	Intentional (directed) mortality; Photograph/ Video	**Spawning documentation 500** Early Life Stage (ELS) collected by artificial substrate; D-nets; epibenthic sampler; seine; & observations by divers.

Species	Listing Unit or Stock	Life Stage	Expected Take	Take Action	Observe/ Collect Method	Procedure	Details
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/ Sub-adult/ Juvenile	2	Unintentional mortality	Net, Gill	Unintentional mortality; Photograph/ Video	Up to 2 **unintentional mortalities/harm** of an adult/sub-adult/juvenile per year, but no more than 1 adult (≥600 mm total length) during life of the 5 year permit
Sturgeon, Atlantic	New York Bight (NMFS Endangered) & Other Mixed DPSs	Juvenile	370	Capture/Handle/ Release	Net, Gill	Capture/recapture, Mark, Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video	**Capture/recapture** of 370 Juveniles (<600 mm total length) by gill nets per year. Collection may also be by trammel nets; traps; trawls; & seines. *Each captured individual may be recaptured up to two times daily. Once this limit is reached, nets will be pulled from the water for the day.
Sturgeon, Atlantic	New York Bight (NMFS Endangered) & Other Mixed DPSs	Juvenile	30	Capture/Handle/ Release	Net, Gill	Anesthetize; Instrument, internal (e.g., VHF, sonic); Mark, Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ video	**Capture and acoustic tagging** up to 30 Juveniles (300 to <600 mm total length) per year, would not sonic tag animals less than 300 mm or if the tag exceeds 2% of body weight. Collection may also include trammel nets; traps; trawls; & seines.
Sturgeon, Atlantic	New York Bight (NMFS Endangered) & Other Mixed DPSs	Juvenile	30	Capture/Handle/ Release	Net, Gill	Anesthetize; Lavage; Mark ,Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video	**Diet Study** where up to 30 Juveniles (300 to <600 mm total length) per year will be subject to lavage procedures. Collection may also include trammel nets; traps; trawls; & seines.
Sturgeon, Atlantic	Range-wide (NMFS Endangered) & Other Mixed DPSs	Adult to Sub-adults	80	Capture/Handle/ Release	Net, Gill	Capture/recapture, Mark, Floy T-bar; Mark, PIT tag; Measure; Other; Sample, Fin clip; Weigh; Photograph/ Video	**Capture** up to 50 adults or subadults (≥600 mm total length) per year
Sturgeon, Atlantic	Range-wide (NMFS Endangered) & Other Mixed DPSs	Adult to Sub-adults	20	Capture/Handle/ Release	Net, Gill	Mark, Floy T-bar; Mark, PIT tag; Measure; Sample, Fin clip; Weigh; Photograph/ Video & Other	**Capture** up to 20 adults/sub-adults (≥500 mm total length) per year, tethered in a **nylon sock and remotely sensed with hydro-acoustic equipment** prior to release.

Species	**Listing Unit or Stock**	**Life Stage**	**Expected Take**	**Take Action**	**Observe/ Collect Method**	**Procedure**	**Details**
Sturgeon, Atlantic	New York Bight (NMFS Endangered) & Other Mixed DPSs	Egg/ Larvae	500	Intentional (Directed) Mortality	Egg mat	Intentional (directed) mortality; Photograph/ Video	**Spawning documentation** of ELS collected by artificial substrate; D-nets; epibenthic sampler; seine; & observations by divers.
Atlantic Sturgeon	New York Bight (NMFS Endangered) & Other Mixed DPSs	Adult, Sub-adult & Juvenile	2	Unintentional mortality	Net, Gill	Unintentional mortality; Photograph/ Video	Up to 2 **unintentional mortalities/harm** of an adult/sub-adult/juvenile per year, but no more than 1 adult (≥1300 mm total length) during life of the 5 year permit

2.2 Proposed Activities under Permit No. 19642

The activities proposed under Permit No. 19642 are comprised of two parts. The first study is to characterize juvenile, sub-adult, and adult life stages, coastal movements, and genetics of endangered Atlantic and shortnose sturgeon in the York, Rappahannock, Potomac, and Susquehanna Rivers, the Chesapeake Bay, and their tributaries (Study 1). The second study includes opportunistically telemetry tagging on legally and incidentally captured Atlantic sturgeon in the Atlantic Ocean from Maine to Florida, to provide monitoring and research activities in collaboration with the entity taking those sturgeon (Study 2). The permit does not allow captures for Study 2, rather, researchers are authorized to only perform further research activities on Atlantic sturgeons that have been previously legally taken (e.g., covered by an Incidental Take Permit or by the Incidental Take Statement of an ESA section 7 biological opinion with a “no jeopardy” conclusion). Should the incidental take statement numbers covered be otherwise reduced during the life of this permit, the number of Atlantic sturgeon used for research by the Permit Holder must not exceed the number authorized by the incidental take statement. The permit would be valid for five years from the date of issuance and would authorize the following proposed methodology for the “take” (Table 2 and Table 3) of Atlantic and shortnose sturgeon throughout the Chesapeake Bay and its rivers and tributaries, and the Atlantic Ocean by Jason Kahn. The requested take of shortnose and Atlantic sturgeon is based on prior Chesapeake Bay sampling and research objectives of the permit holder, Jason Kahn, over the next five years.

Table 2. Study 1: Proposed "takes" of ESA-listed sturgeon during Jason Kahn's research activities in the Chesapeake Bay and surrounding waters under Permit No. 19642. Both male and female animals are represented in the table.

Species	Listing Unit or Stock	Life Stage[2]	Expected Take	Take Action	Observer/Collect Method	Procedure	Details
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/Sub-adult/ Juvenile	30	Capture/ Handle/ Release		Floy T-bar; PIT tag; Measure; Sample, Genetic fin clip; Weigh; Photograph/ Video	**Capture/Recapture to Document Presence/Absence** **adult = (x ≥ 600mm FL)** **sub-adult = (450 ≥x<600 mm FL)** **juvenile = (x < 450 mm FL)** *Each captured individual may be recaptured up to three times daily. Once this limit is reached, nets will be pulled from the water for the day.
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/Sub-adult/ Juvenile	20	Capture/ Handle/ Release		Anesthetize; Instrument internal tag (e.g.VHF sonic); Floy/T-bar; PIT tag; Measure; Sample, Genetic fin clip; Weigh; Photograph/ Video	**Acoustic tagging** (**Note:** No more than 50 fish tagged during permit) (**Note**: External tags (e.g.,VHF, satellite) w/o anesthesia used in circumstances where long-term tag retention is not critical)
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Egg/ Larvae	500	Intentional (Directed) Mortality		Collect Eggs/Larvae Intentional (directed) mortality; Photograph/ Video; Take preserved samples to lab	**Spawning Documentation** ELS collected by artificial substrate; D-nets, epibenthic sampler, seine and diver
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/Sub-adult/ Juvenile	1	Unintentional Mortality		Unintentional Mortality	**Unintentional Mortality** (**Note**: Up to 1/yr of any life stage; but no more than 1 adult killed over permit term of 5 yrs (x ≥ 600 mm FL)

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[2] Both males and females would be authorized for take.

Atlantic Sturgeon	Chesapeake Bay (NMFS Endangered	Adult Sub-adult Juvenile	75	Capture/ Handle/ Release		Anesthetize; Instrument Internal (e.g., VHF, sonic); Floy T-bar; PIT tag; Measure; Sample, Genetic fin clip; Weigh; Photograph/ Video	**Acoustic tagging** Could affect any DPS because of sub-adult migration; but adults and juveniles would be the preferential target. **adult = (x ≥ 1300mm FL)** **sub-adult = (500 ≥ x < 1300 mm FL)** **juvenile = (x < 500 mm FL)** (**Note**: External tags (e.g.,VHF, satellite) w/o anesthesia in circumstances where long-term tag retention is not critical) (**Note**: Only 30 tagged/ river/year; and only 75 tagged/river/ 5 years)
Atlantic Sturgeon,	Chesapeake Bay (NMFS Endangered	Adult/ Sub-adult/ Juvenile	200	Capture/ Handle/ Release		Floy T-bar; PIT tag; Measure; Sample, genetic fin clip; Weigh; Photograph/ Video	**Capture/Recapture for Population Studies** Could affect any DPS because of sub-adult migration; but adults and juveniles would be the preferential target. *Each captured individual may be recaptured up to three times daily. Once this limit is reached, nets will be pulled from the water for the day.
Atlantic Sturgeon,	Chesapeake Bay (NMFS Endangered	Adult/ Sub-adult/ Juvenile	100	Capture/ Handle/ Release		Instrument, External (e.g., VHF, satellite); and Instrument Internal (JSAT tag w/o anesthesia); Floy T-bar; PIT tag; Measure; Genetic fin clip; Weigh; Photograph/ Video	**Experimental Dual Tagging** Could affect any DPS **Note**: Up to 100 dual tags/yr, including external tag paired with internal JSAT tag (JSAT = injectable w/o anesthesia) (**Note:** No more than 35 fish per river/year may be tagged) *Each captured individual may be recaptured up to three times daily. Once this limit is reached, nets will be pulled from the water for the day.

Atlantic Sturgeon	Chesapeake Bay (NMFS Endangered	Eggs/ Larvae	500	Intentional (Directed) Mortality		Collect Eggs/Larvae Intentional (directed) mortality; Photograph/ Video; Take preserved samples to lab	**Document Spawning** ELS collected by artificial substrate; D-nets, epibenthic sampler, beach seine and diver
Atlantic Sturgeon	Chesapeake Bay (NMFS Endangered	Adult/ Sub-adult/ Juvenile	2	Unintended Mortality		Unintentional Mortality	**Unintentional Mortality** (**Note**: Up to 2/ yr of any life stage; But no more than 1 adult killed over permit term. (x ≥ 1300 mm FL)

Table 3. Study 2: Shortnose and Atlantic Sturgeon Captured (Year-round) by "Other" Incidental Authority in Permit No. 19642.

Species	Listing Unit or Stock	Life Stage	Expect Take	No. Takes	Take Action	Procedure	Details
Shortnose Sturgeon	Range-wide (NMFS Endangered)	Adult/Sub-adult/ Juvenile	50	1	Handle/ Release	Anesthetize and Instrument internal (e.g. VHF sonic); Floy/T-bar; PIT tag; Measure; Sample, Genetic fin clip; Weigh; Photograph/ Video	**Acoustic tagging** **Note**: "Other" = Captured by any incidental authority (e.g., Incidental Take Permit or Incidental Take Statement) (**Note**: External tags (e.g., VHF, satellite) w/o anesthesia used in circumstances where long-term tag retention is not critical)
Atlantic Sturgeon	Any DPS (NMFS Endangered; or Threatened)	Adult/ Sub-adult/ Juvenile	50	1	Handle/ Release	Anesthetize and ; Instrument Internal (e.g., VHF, sonic); , Floy T-bar; PIT tag; Measure; Sample, Genetic fin clip; Weigh; Photograph/ Video	**Acoustic tagging** (**Note**: "Other" = Captured by any incidental authority (e.g., Incidental Take Permit or Incidental Take Statement) (**Note**: External tags (e.g., VHF, satellite) w/o anesthesia used in circumstances where long-term tag retention is not critical)
Atlantic Sturgeon,	Any DPS (NMFS Endangered; or Threatened)	Adult/Sub-adult/ Juvenile	150	1	Handle/ Release	Floy T-bar; PIT tag; Measure; Sample, genetic fin clip; Weigh; Photograph/ Video	**Handle & Release** (**Note**: "Other" = Captured by any incidental authority (e.g., Incidental Take Permit or Incidental Take Statement)

2.2.1 Capture by anchored, drift, and trammel gill nets

Sampling with anchored, drift, and trammel gill nets will be performed in two distinct phases each year of the study for activities conducted under Permit No. 19331. The first phase will target overwintering shortnose sturgeon from November through March in the tidal Delaware River between Roebling and Trenton, New Jersey (approximately rkm 186 to 215). The second phase will target Atlantic and shortnose sturgeon from May through October throughout the Delaware River from Artificial Island to Trenton, New Jersey (approximately rkm 79 to 215). Research activities will include the area from rkm 0 to 215.

For activities conducted under both proposed permits, gill nets of 12.7 cm (5-inch) to 15.2 cm (6-inch) stretched mesh would be used to sample for adult shortnose and juvenile and sub-adult Atlantic sturgeon. Gill nets of 2.5 cm (1-inch) to 12.7 cm (5-inch) stretched mesh would be used to sample for juvenile shortnose and Atlantic sturgeon. Larger 15.2 (6-inch) to 25.4cm (10-inch) gill nets would target sub-adult and adult Atlantic sturgeon. Gill nets would typically be 100 m in length and 1.8 m deep, although shorter nets may sometimes be used. Anchored gillnets will be fished in water temperatures at the deepest depth sampled by the gear for the entire duration of deployment between 0°C and 28°C, and at dissolved oxygen concentrations of 4.5 mg/l or greater; however, at temperatures less than 7ºC, and above 27°C, research activities will be limited to non-invasive procedures only (i.e., PIT and T-bar tag, measure, weigh, photograph, and genetic tissue clip).

Table 4. Summary of environmental conditions for anchored gillnetting for Permit No. 19331.

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	Maximum Net Set Duration (h)
0 < 10	4.5	10.0[1]
10 ≤ 15	4.5	4.0[2]
15 ≤ 20	4.5	2.0[2]
20 ≤ 27	4.5	1.0
27≤ 28	4.5	0.5
>28	N.A.	Cease Netting

1. Nets in daylight sets only, will be made between 0 and 10ºC in shortnose sturgeon overwintering aggregation areas for population estimate studies. Nets will be checked at least every two hours
2. Nets will be checked every two hours; but will also be continually monitored and pulled when a catch is evident.

Table 5. Summary of environmental conditions for anchored gillnetting for Permit No. 19642.

Water Temperature (ºC)	Minimum D.O. Level (mg/L)	Maximum Net Set Duration (h)
0 < 15	4.5	14.0[1]
0 ≤ 15	4.5	4.0[2]
15 ≤ 20	4.5	2.0[2]
20 ≤ 25	4.5	1.0[2]
27≤ 28	4.5	0.5[2]
>28	N.A.	Cease Netting

1. Net-set duration of 14 hours (including unattended, overnight) is limited to fresh water (<2.0 ppt) ranges where unidentified populations or life stages may exist.
2. Net sets must be continuously monitored and checked upon a net strike by targeted or non-targeted catch.

Drift nets will be used to target juvenile Atlantic sturgeon in the Marcus Hook area of the river south of Philadelphia. Sampling with gill nets would be based on the appropriate habitat to use active drift gill nets (McCord et al. 2007). The nets would be set by the researchers and coordinates would be marked with a Global Positioning System (GPS) at preferred sites, which include flat bottom, free of snags, away from heavy ship traffic, and out of the main channel in 3 to 16 meters (m) of depth. Sites where sampling is not possible, either through loss of gear or having extensive bottom structure, would be eliminated from sampling. Gillnets would be set at slack tide, perpendicular or diagonal to the tidal current, and tended closely by ERC, Inc. researchers until the onset of the next tide. Each set would soak for 30 minutes (min) to 2 hours (h) before it is retrieved, with a 4 h maximum with water temperature less than 15°C. Gill nets would have a predetermined maximum deployment time dictated by water temperature, and dissolved oxygen (Table 2, adapted from Kahn and Mohead 2010). To maximize chances of catching sturgeon, nets 92 m in length with a small mesh (6, 9 or 10 cm stretch mesh) on the lower 2 m of net would be configured to make contact with the bottom (McCord et al. 2007). A variety of size and age classes would be captured in these gill net sets, including late stage juveniles, early stage juveniles, and potentially adults.

Trammel nets will be anchored on the bottom and fished at water depths comparable to gill nets. Trammel nets will range from 50 meters to 90 meters in length and two meters in depth, made of heavy multifilament nylon mesh instead of monofilament or light twine, will typically consist of 5.1 cm (2-inch) to 10.2 cm (4-inch) mesh size for the inner panes, and 20.3 cm (8-inch) to 30.5 cm (12 inch) in the outer panels. Experimental trammel nets could vary depending on the targeted animal. The same standardized netting protocol (duration, temperature and D.O.) as described above for gill nets will be followed for bottom set trammel nets.

2.2.2 Capture by trawling

Trawling will sample juvenile Atlantic and shortnose sturgeon in the Delaware River. Dovel and Berggren (1983) found that small trawls were effective for such collecting in the Hudson River. Trawling for juvenile shortnose and Atlantic sturgeon will be performed in the tidal Delaware River from Artificial Island to Trenton (rkm 75 to 215) using a 4.9 m otter trawl and/or a 14.6 m

Yankee trawl (Table 6). In the Chesapeake Bay, under Permit No. 19642, trawl nets of 2.4 m by 4.8 m will be used with a variety of cod ends developed to target sturgeon of different sizes and depending on the time of year.

Table 6. Description of Proposed Trawling Gear

	4.9 m Otter Trawl	**14.6 m Yankee Trawl**
Headrope (m)	5.2	14.6
Footrope (m)	6.4	21
Net body mesh (mm)	38 & 50	80
Codend mesh (mm)	32	50
Innerliner mesh (mm)	13 & 5	14

Trawl nets will be towed at a maximum speed of 2.5 knots (5 miles per hour), for 10 to 15 minutes. Bottom areas of anticipated sampling will be evaluated with sonar devices prior to trawling to determine if substrate suitable and is free from snags. Trawling would be conducted primarily over sand substrates avoiding hard bottoms, vegetated areas, organic material, or woody debris. If a trawl net snags on bottom debris, it will be untangled immediately to reduce stress on captured animals. To lessen benthic disturbances, trawl nets will not be towed over the same exact location more than once in a 24 hour period using a sonar scanning device and global positioning system (GPS).

2.2.3 Capture by pound nets and other trapping nets

The researchers proposed using pound, fyke and other trap nets opened to the surface, for fishing in waters near the cooling water intakes of industrial plants. In general, these are 6 by 9 m long, stationary trapping gears, beginning with a length of netting called the "leader," and stretching out perpendicular from the shoreline. The leader does not actively capture fish; it spans the depth of the water column, diverting fish away from shore and into the trap (or pound) located offshore. The pound nets are typically linked together in chains and equipped with wings and leaders. These nets can be deployed without continuous checking for up to 24 hours. Additionally, pound nets may be used as holding pens along the riverbank, where fish may be held for up to two hours.

2.2.4 Capture by beach seines

Beach seines, operated from the shore, are proposed for targeting young of year or juvenile sturgeon, foraging along flat sandy areas of rivers and estuaries that are unable to out-swim the hauling action of the seine. In particular, this method is proposed to be effective for sampling areas near cooling water intake structures of industrial plants; but would also be effective at documenting spawning activity. The seine is lengthened by long ropes for towing; then encircles and draws the fish towards the beach. The seine provides a barrier, preventing the fish from escaping the area enclosed by a centered bag portion of the net when surrounded. The head-rope of the seine (approximately 30 meters long) would be fitted with floats on the surface and the footrope would remain in permanent contact with the bottom weighted lead 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 river bottom and surface also act as natural barriers. When drawing the lead line of a beach seine close to shore, animals will be pooled in clearer waters with minimal turbidity. The drag lines would be towed simultaneously from the beach, herding the fish to the front of the bag. Once the ground ropes reach the beach, the catch would be gathered by the centered bag by bringing the gear underneath the fish. The bycatch would be sorted and returned to the water and all sturgeon would be then be sized and weighed and, if appropriate, PIT tagged. Larval samples may be preserved for later identification while others fish will be handled and released within 30 minutes after pooled along the shoreline.

2.2.5 Larval sampling by egg mats, D-nets, and epibenthic sleds

Deployment of artificial substrates, D-nets, or epibenthic sleds will be used for lethally collecting sturgeon eggs and larvae up to the limit described in the take table (Table 2 and Table 3) for each river. Eggs and larvae may be transported back to the lab for species verification and preservation in 95 percent ethyl alcohol, and the remainder will be returned to the river at the site of collection.

D-nets will be set to collect eggs and larvae floating downstream below spawning grounds. Under Permit No. 19331, D-Nets will be set for a maximum duration of three hour intervals before checking, and under Permit No. 19642, D-nets will be set for 30 minutes at a time. These D-frame nets will consist of framed nets 76 cm across the base and 54 cm high, and will be fitted with a knotless 1600 µm mesh nylon bag 317.5 cm long with a detachable cod end. The passive ichthyoplankton nets will be set on the bottom, for durations of approximately one to three hours, within and downstream of probable spawning locations (Auer and Baker 2002; Taubert 1980b).

Under Permit No. 19331, egg mats will be fished as necessary and checked at least twice per week, while under Permit No. 19642, egg mats will be checked every two to three days through the spawning season. 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 Jr. and Beckman 1993). Egg mats/D-nets will be removed from rivers once the water temperature exceeds 25°C, reaches 0°C, or the authorized numbers of sturgeon eggs and/or larvae of each species have been collected, whichever comes first. The egg mats are artificial substrates, consisting of floor buffing pads (McCabe Jr. and Beckman 1993) anchored to the river bottom using concrete pavers and marked with a float. The artificial substrates will be deployed in a stratified fashion downstream of spawning activity to cover habitats likely to support settling of early life stages. Each will be examined in the field for sturgeon eggs or larvae, photographed, and immediately returned to the river.

A towed epibenthic sled fitted with an ichthyoplankton net similar to the net described above may also be used if suitable. The ichthyoplankton nets will be equipped with a flow meter to measure volume of water filtered. The epibenthic sled sampler may be towed against the prevailing current for up to five minutes, at an average speed of approximately 1.0 m/second through the water.

2.2.6 Recaptures

In anticipation of recaptures, ERC, Inc. will be permitted to capture each individual juvenile Atlantic and shortnose sturgeon up to two times annually (one initial capture, followed by a potential recapture). Each time a fish is captured (whether it was a recapture or not), it will count towards the number of takes authorized in the permit (Table 1). If a fish is recaptured, the researchers would document the health of the recaptured fish and take new weight and length measurements, in addition to recording the healing rates of any incisions, sutures, or implanted tags. The researchers would modify or adapt any research activity that appears to be harmful.

2.2.7 General sampling techniques

A variety of general techniques will be used on captured sturgeon including handling of holding of individuals, collection of tissue samples, insertion of internal tags, attachment of external tags, gastric lavage, and fin ray clipping. The techniques of each of these activities is described below.

2.2.8 Handling and holding

The proposed activities would include the general handling of all captured Atlantic and shortnose sturgeon in accordance with "A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons" (Kahn and Mohead 2010). Individuals would be weighed (g) by a hanging scale and a moist nylon mesh bag, measured on a flat wet board to fork length and total length, examined for tags, marked with a Passive Integrated Transponder (PIT) tag and a numbered Floy T-bar tag, sampled (i.e., genetic fin clip), photographed, and released (Table 2 and Table 3). A subset of these individuals would undergo additional handling as described below. To confirm species identification, the mouth width and interorbital width would be measured with calipers (Moser et al. 2000). If time allows, sturgeon would be photographed/videoed.

Once captured, sturgeon would be transferred and held temporarily in flow-through holding tanks or in boat-side net pens measuring for weighing, measuring, and further sampling. To minimize handling effects, sturgeon would be supported using a sling or net while moving, and moved and handled by researchers using smooth rubber gloves. When in onboard holding tanks, sturgeon would be immersed in a continuous stream of water. Holding tanks would allow for total replacement of water volume every fifteen minutes and aerated as necessary during periods of high temperature and/or low dissolved oxygen to ensure dissolved oxygen concentrations do not fall below acceptable levels (Kahn and Mohead 2010). An electrolyte will be added to the water in the holding tank.

Handling of fish would be kept to a minimum and total holding time of any one sturgeon would not exceed two hours. Processing time of any one sturgeon would not exceed twenty minutes, not including recovery time from anesthesia in the live car or holding tank. Fish receiving surgically-implanted transmitters would be held only until the fish has recovered from the anesthesia and surgery.

2.2.9 Marking and tagging with PIT, floy T-bar tags, and JSAT Tags

Passive integrated transponder (PIT) tags would be used to individually identify all captured fish not previously tagged. PIT tags are internal and act as a lifetime barcode for an individual animal. They are dormant until activated by an electromagnetic field generated by a close-range scanning device (Smyth and Nebel 2013). The entire dorsal surface of each fish would first be scanned with a waterproof PIT tag reader and visually inspected to ensure detection of fish tagged in other studies. Previously PIT-tagged fish would not be retagged. The researchers under permit 19331 would insert 8.4 mm by 1.4 mm PIT tags in juvenile Atlantic or shortnose sturgeon measuring between 250 mm and 350 mm total length. Larger sturgeon would receive PIT tags 11.5 mm by 2.1 mm in diameter. Under Permit No. 19642, researchers will use 12 mm PIT tags in all sturgeon above 300 mm in total length. Prior to placement of PIT tags, the injection needle and site would be sanitized with a disinfectant such as isopropyl alcohol. PIT tags would be injected in the 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.

Numbered Floy T-bar tags would be inserted in animals measuring $\geq$350 mm (for Permit No. 19331) and $\geq$300 mm (for Permit No. 19642) total length or above for external identification, however, the total weight of all tags must not exceed 2 percent of a sturgeon's total body weight. T-bar tags are commonly used to identify fish that may be captured in distant locations by other researchers or fishermen. NMFS recommends the use of external identification tags (e.g., T-bar tags) on sturgeon species with distant migrations (e.g., Atlantic sturgeon) (Kahn and Mohead 2010). For insertion, numbered T-bar tags would be anchored in the base of the dorsal fin musculature by inserting the injector forward and slightly downward from the left side to the right through the dorsal pterygiophores.

Pop-off satellite tags may also be used for external tagging into the sturgeon’s dorsal fin using a monofilament tether, without anesthesia. Researchers under Permit No. 19642 may utilize experimental injectable tags, referred to as JSATS (Juvenile Salmon Acoustic Telemetry System), for internally tagging Atlantic sturgeon (without anesthesia) and also in combination with external tags. However, prior to using JSAT tags, the Permit Holder will consult with the NMFS Permits Division. The injectable JSAT tag is a 1.5 cm long acoustic tag with a 100 day life-span, which can be injected in any sturgeon life stage (>300 mm) without surgery or anesthesia, similar to a PIT tag in order to obtain information on in-river movement, habitat use, and residence times.

2.2.10 Anesthesia

The researchers may use either tricaine methanesulfonate (MS-222) or electronarcosis to anesthetize fish.

2.2.10.1 Anesthesia with MS-222

Shortnose and Atlantic sturgeon selected for internal surgeries or gastric lavage would be anesthetized using MS-222 with a dose of up to 150 mg/L. Animals would be observed carefully to assess full narcotic state in preparation for invasive procedures. Movement and equilibrium would be monitored throughout to determine the depth of anesthesia and to ensure a stable and living condition of the animal. Upon completion of the surgery or lavage procedure, the fish would be returned to fresh water in either the live well of the boat or a boat-side net pen in and assisted with ventilation by slowly moving the fish back and forth in the water while gently supporting it by the tail and under the body. Researchers will be fully trained and experienced in use of MS-222 for anesthetizing sturgeon.

2.2.10.2 Anesthesia with Electro-narcosis

When anesthetizing individuals in freshwater (< 3 ppt salinity), researchers would use the method described by Henyey et al. (2002), using non-pulsed direct current voltage (0.3 to 0.5 V/cm, 0.01 amp). In this procedure, fish would be placed in a tank having an anode screen at one end of the tank and a cathode screen at the other end. Amperage would be minimized throughout the procedure. As voltage is applied quickly to the anode (1 to 2 sec), the subject fish would lose equilibrium and relax, sinking to the bottom. Voltage would then be adjusted downward until the fish becomes immobilized except for strong opercula movement. Fish would then be supported with a netting sling so only their ventral surface is emerged from the water before work is conducted and during work. All co-investigators authorized in the permit would receive supervision and experience in the use of electro-narcosis prior to anesthetizing sturgeon with electro-narcosis.

2.2.11 Internal acoustic tagging

Each year, a subset of juvenile Atlantic and shortnose sturgeon would be anesthetized and implanted surgically with acoustic transmitters.

Sturgeon of either species selected for acoustic tagging would be implanted with a transmitter of appropriate size, not to exceed 2 percent body weight in air to ensure normal mobility. Adult shortnose sturgeon will be tagged with VEMCO V16-5H or V13 acoustic tags. Juvenile (≥ 300 mm) shortnose and Atlantic sturgeon will be tagged with VEMCO V7-4L or V9-6L, depending on the weight of the individual sturgeon. Specifications for these transmitters are detailed in Table 7, and researchers under Permit No. 19642 would solely use V16-5h tag models.

Table 7. Proposed Vemco Acoustic Tag Models and Specifications.

Model	Length	Diameter	Weight (H^{2}0)	Weight (O^{2})
V7-4L	22.5 mm	7 mm	1.0 g	1.8 g
V9-6L	21.0 mm	9 mm	1.6 g	2.9 g
V13-1H	36.0 mm	13 mm	6.0 g	11.0 g
V16-5H	95.0 mm	16 mm	16.0g	36.0 g

Prior to tag implantation, the individual would be anaesthetized using up to 150 mg/L of MS-222 or electro-narcosis and then held upside down in a cradle where the gills will be perfused with aerated flowing water. The dosage used may vary but would be appropriate for sturgeon under the specific water temperature and oxygen conditions and would follow the methods reported by Kahn and Mohead (2010).

The transmitter and all surgical instruments would be sanitized with povidone iodine (10 percent solution) immediately prior to use and the incision site cleansed A new scalpel will be used with each surgery, making a small longitudinal abdominal incision just large enough for the transmitter. A small ventral incision would be made anterior to the pelvic fins, parallel and adjacent to the ventral midline where the body width is greatest. A transmitter would then be inserted into the body cavity and the incision would be closed with interrupted sutures of 3-0 polydioxanone (PDS) and treated with a Vaseline/povidone iodine mixture to prevent infection. To ensure proper closure, either uninterrupted running or a single interrupted suturing technique would be applied. Post-surgery, fish will be held in an aerated holding tank and released upon recovery from anesthesia. Based on the researcher’s experience, the surgical procedure will require approximately five minutes to complete, with a total holding time (anesthesia induction, surgery, and recovery) of twenty minutes or less. Surgery to implant transmitters would only be attempted when fish are in excellent condition and if the water temperature exceeds 27°C (to reduce handling stress) or is less than 7°C (incisions do not heal rapidly in low temperatures). No other invasive procedure would be performed on fish undergoing implantation of acoustic transmitters.

2.2.12 Gastric lavage (Atlantic sturgeon diet study)

For Permit No. 19331, the stomach contents of 30 selected juvenile (300 to < 600 mm total length) Atlantic Sturgeon annually would be sampled for diet analysis throughout the spring, summer/fall and winter season using gastric lavage (Collins et al. 2008; Haley 1998). Fish selected for gastric lavage would be anesthetized using up to 150 mg/L of MS-222 or electro-narcosis to relax the fish prior to the procedure. Using a flexible polyethylene tube, researchers would pass the tube carefully through the sturgeon's alimentary canal and verified to be properly positioned in the stomach by feeding the tubing from the fish's ventral surface. Researchers would carry out gastric lavage using a 1.90 mm diameter flexible tubing on sturgeon between 250 mm and 350 mm (FL); 4.06 mm diameter flexible tubing on sturgeon between 350 mm and 1250 mm (FL); and 10.15 mm flexible tubing may be used on sturgeon over 1250 mm (FL). Gastric lavage would be then be carried out by gently flooding the stomach cavity with water delivered from a lightly pressurized garden sprayer. The fish would be allowed to recover in an aerated holding tank or floating net pen prior to release back to the river. The entire procedure, including anesthetizing, would take three to eleven minutes (Collins et al. 2008). No other invasive procedure would be performed on fish undergoing gastric lavage.

2.2.13 Recovery from surgery and anesthesia

Following anesthesia and surgery, all captured individuals would be placed in a live-well within the boat or a boat-side net pen to recover. By holding the fish upright prior to release, and immersed in river water, animals would be gently moved front to back, passing freshwater over the gills to stimulate the fish. The fish would only be released when showing signs of being able to swim away strongly. A spotter would be present, watching to ensure the fish stays down and does not need additional recovery time. Total time for recovery is typically five minutes, with a holding time of twenty minutes or less. Handling time for sturgeon not receiving an anesthetized procedure should be less than two minutes with recovery under thirty seconds. Researchers will be trained in these techniques.

2.2.14 Biological tissue sampling

Genetic information would be obtained from tissue samples of all captured Atlantic and shortnose sturgeon to help characterize the genetic "uniqueness" of the Delaware River and Chesapeake Bay populations and would also help quantify the current level of genetic diversity within the population. Immediately prior to release, a small (1.0 cm^2) soft fin tissue sample would be collected from the trailing margin of the pelvic or caudal fin using sanitized scissors. Tissue samples would be preserved in individually labeled vials containing 95 percent ethanol. Genetic tissue samples collected from shortnose and Atlantic sturgeon for archival purposes would be sent to the NOAA Tissue Archive, or to co-investigators identified in the permit. Proper certification, identity, and chain of custody of samples would be maintained during transfer of tissue samples.

2.2.15 Hydro-acoustic testing

Selected shortnose and Atlantic sturgeon under Permit No. 19331 (Table 3) would be scanned using fishery hydro-acoustic and/or sonar equipment as part of an evaluation of technologies for remote detection and identification of sturgeon (Brundage and Jung 2009; Nealson and Brundage 2007). Sturgeon tested with hydro-acoustics/sonar would be scanned while still in nets or while tethered using soft-fabric (nylon or cotton) mesh sleeves for periods not exceeding two hours when water temperature and D.O. concentration are below 20°C and above 4.5 mg/L respectively. The objectives of this investigation would be to: 1) determine if adult shortnose sturgeon can readily be detected with hydroacoustic/sonar systems under varying field conditions; 2) determine how close to the bottom the species can be resolved; and 3) determine the efficiency and characteristics of the technology which would best enable sturgeon to be remotely identified and enumerated in a mixed-species environment.

The proposed methods will follow Brundage and Jung (2009), where the researchers captured sturgeon and three other non-listed fish species for hydro-acoustic data collection using anchored bottom-set gill nets. In their study, hydro-acoustic measurements were first collected by passing over the netted fish with a downward looking broadband sonar transducer. Following acoustic data collection, the netted fish were recovered, identified, and measured for total length.

In the present study, researchers would typically collect data over a frequency range of 110 to 220 kilohertz, using a pulse length of one meter and an acoustic pulse repetition rate of three pings per second. Additionally, the proposed data collection will include using ping rates higher than those used by Brundage and Jung (2009), by using both broadband and narrowband sonar at ping rates over 30 pings per second, alternating between broadband single-beam and narrowband split-beam signals. Narrowband split-beam processing allows for locating a target with an accurate bearing angle, and the broadband spectrum can be adjusted according to transducer sensitivity and the beam plot across the band. Thus, the researchers also propose to collect data from fish tethered in a specially designed frame (or sock) where the aspect angle can be controlled, obtaining enhanced detail and specifications, similar to that used by Jung et al. (2004) with salmon smolts.

2.2.16 Tracking telemetry

After releasing juvenile Atlantic and shortnose sturgeon implanted with acoustic transmitters under Permit No. 19331, sturgeon movements would be monitored using both active and passive tracking techniques. Active tracking would occur using a VEMCO® VR100 receiver and two hydrophones (directional and multi-directional). During manual tracking events, the locations of tagged fish would be determined through standard telemetry techniques and recorded using GPS coordinates. A passive telemetry array is maintained throughout the Estuary consisting of VR2W receivers at locations from rkm 0 to 214; the number and location of receivers may vary based on available funds and logistical concerns. These receivers are attached to United States Coast Guard Aids to Navigation buoys. Sampling areas may be modified in the future depending on results obtained from tracking sturgeon movement and habitat use.

For Permit No, 19642, after releasing Atlantic and shortnose sturgeon tagged with telemetry tags, researchers will track their movements through an array maintained by the U.S. Navy through the Chesapeake Bay and along the Virginia Coast, as well as cooperatively with other groups through data sharing along the entire Atlantic Coast.

2.2.17 Incidental mortality or harm

Under Permit No. 19331, the Permits Division proposes to authorize two unintentional mortalities per year of each sturgeon species (of any life stage), but not more than one adult (≥600 mm for shortnose, and ≥1300 mm for Atlantic sturgeon) of each species during the five years of the permit. Additionally, under Permit No. 19642, the Permits Division proposes to authorize one shortnose sturgeon unintentional mortality per year and two Atlantic sturgeon unintentional mortalities per year (of any life stage), but not more than one adult (≥ 600 mm for shortnose, and ≥ 1300 mm for Atlantic sturgeon) of each species during the five years of the permit. If a greater incidence of mortality or serious injury should occur, the Office of Protected Resources would need to be consulted to determine the cause of mortality and to discuss any remedial changes in research methods. The Permits Division could grant authorization to resume permitted activities based on review of the incident depending on the circumstances, or suspend research activities.

2.2.18 Permit conditions

The objectives of the permitted activities, as described in the applications, are to document nursery areas, individual movement patterns, seasonal movements, home ranges, and habitat usage, juvenile shortnose sturgeon and juvenile Atlantic sturgeon, in the Delaware River and Bay and the Chesapeake Bay area. The proposed permits contain terms and conditions intended to minimize potential adverse effects of research activities on ESA-listed sturgeon. The terms and conditions developed by the Permits and Conservation Division are included in draft Permit No. 19331 and No. 19642.

2.3 Action Areas

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 CFR 402.02).

2.3.1 Permit No. 19331 action area

The action area under these proposed activities would be the Delaware Bay, tidal river, and freshwater sections of the Delaware River extending from the mouth of the Delaware Bay (rkm 0) to just upstream of Lambertville, New Jersey (rkm 245) (Figure 1). The Delaware River is one of the major rivers of the eastern United States draining an area of 31,000 square kilometers (sq km). It borders Pennsylvania and New Jersey, and follows a generally eastward course to its mouth in the Delaware Bay. The last 100 km is bounded by New Jersey to the north and Delaware to the south (DRBC 2009).

The Delaware Estuary varies in width from 18 km between Cape May, New Jersey, and Cape Henlopen, Delaware; to 43 km at its widest point (near Miah Maull Shoals). The Delaware Bay region of the estuary is 72 km extending from the Capes to a line between stone markers at Liston Point, Delaware and Hope Creek, New Jersey (Polis and Kupferman 1973). Water depth in the bay is less than 9 m in 80 percent of the bay, excluding the dredged channel, and is less than 3 m deep in much of the tidal river area. Artificial Island (rkm 79) is located approximately 7 km upstream of the hypothetical line demarking the head of Delaware Bay. The tidal river upstream of this area narrows makes a northwesterly 60 degree bend accentuated by Artificial Island on the New Jersey shore. More than half of the typical river width in this area is relatively shallow — less than 5.5 m — while the deeper part, including the dredged channel has depths of up to 12.2 m. The Delaware River between Philadelphia (rkm 161) and Trenton (rkm 215) is tidal freshwater with semidiurnal tides. Mean tidal range at Philadelphia, Pennsylvania is 1.8 m (NMFS 2011), and water pH generally is about 6 to 8.

The freshwater portion of the action area extends above the fall line at Trenton, New Jersey (rkm 215) to just north of Lambertville, New Jersey (rkm 245), and is characterized by bottom substrate consisting of rocky shoals and cobble substrate suitable for shortnose sturgeon spawning habitat.

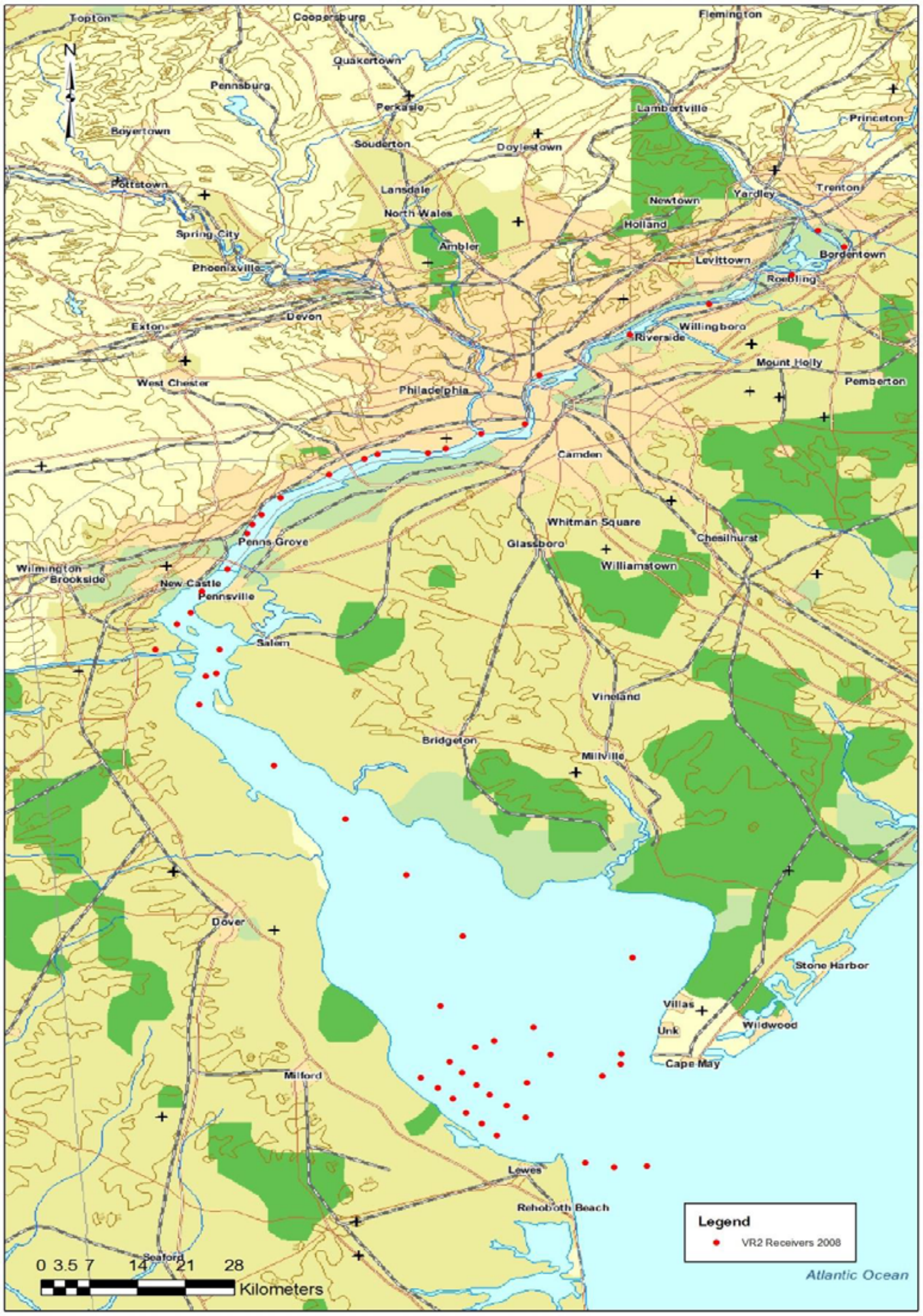

Figure 1. The action area for proposed research under Permit No. 19331.

2.3.2 Permit No. 19642 action area

The action area under the proposed activities for Study 1 of this permit would include the Chesapeake Bay, and all tributaries to the bay with a focus on the York, Rappahannock, Potomac, and Susquehanna Rivers, ranging from river mile 0 to river mile 400.

The action area of Study 2 of the permit encompasses the Atlantic Ocean and all tributaries to the ocean from Maine, south to Florida, including: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida.

2.4 Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. NMFS determined that there are no interrelated and interdependent actions outside the scope of this consultation.

3 APPROACH TO THE ASSESSMENT

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions either are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"To jeopardize the continued existence of a listed species" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). The jeopardy analysis considers both survival and recovery of the species.

The adverse modification analysis considers the impacts on the conservation value of designated critical habitat.

3.1 Overview of the Assessment Framework

We will use the following approach to determine whether the proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

a. Identify the range-wide status of the species and critical habitat likely to be adversely affected by the proposed action.

b. Describe the environmental baseline in the action area including:
   - The past and present impacts of Federal, state, or private actions and other human activities in the action area.
   - The anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation.
   - The impacts of state or private actions that are contemporaneous with the consultation in process.

c. Analyze the effects of the proposed action on both species and their habitat.
   - We consider how the proposed action would affect the species' reproduction, numbers, and distribution.
   - We evaluate the proposed action's effects on critical habitat features.

d. Describe any cumulative effects in the action area.
   - Cumulative effects, as defined in our implementing regulations (50 CFR §402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

e. Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.

  - We add the effects of the action to the *Environmental Baseline* and the *Cumulative Effects* to assess whether the action could reasonably be expected to:
    - Reduce appreciably the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or
    - Reduce the conservation value of designated or proposed critical habitat. These assessments are made in full consideration of the Status of the Species and critical habitat.

f. Reach jeopardy and adverse modification *Conclusion*. In this step we state our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat. These conclusions flow from the logic and rationale presented in the *Integration and Synthesis*.

g. If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

3.2 Risk Analysis for Endangered and Threatened Species

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 populations 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 population 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 individual's "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 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 of these measures) of the populations those individuals represent (Stearns 1992b). A reduction in at least one of these variables (or one of the variables we derive from them) is itself a necessary condition for reductions in a species' viability. As a result, when listed 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 (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992a). 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 animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of 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 the Species* 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 such reductions are likely to be appreciable.

3.3 Evidence Available for the Consultation

To conduct these analyses, we rely on all of the evidence available to us. This evidence consists of monitoring reports submitted by past and present permit holders, the information provided by the Permits Division when it initiates formal consultation, and the general scientific literature.

During this consultation, we conducted electronic searches of the general scientific literature. These searches specifically try to identify data or other information that supports a particular conclusion (for example, a study that suggests whales will exhibit a particular response to approach) as well as data that does not support our conclusion. When data are equivocal, or in the face of substantial uncertainty, our decisions are designed to avoid the risks of inaccurately concluding that an action would not have an adverse effect on listed species.

4 STATUS OF ESA-LISTED SPECIES

This section identifies the ESA-listed species that may be affected by the issuance of Permit No. 19331 and No. 19642 (Table 8). It then summarizes the biology and ecology of those species and what is known about their life histories in the action area. The ESA-listed species potentially occurring within the action area are in Table 8, along with their regulatory status.

Table 8. ESA-listed species that may be affected by the Permits Division's issuance of Permit No. 19331 and No. 19642 for scientific research on Atlantic and shortnose sturgeon in the Delaware River and Chesapeake Bay.

Species	ESA Status	Critical Habitat	Recovery Plan
Sea Turtles			
Green Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	63 FR 46693	1991
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	75 FR 12496
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic DPS	T – 76 FR 58868	79 FR 39856	
Fishes			
Shortnose Sturgeon (*Acipenser brevirostrum*)	E – 32 FR4001	-- --	63 FR 69613
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)			
Atlantic Sturgeon, Gulf of Maine DPS	T – 77 FR 5880	81 FR 35701 (Proposed)	-- --
Atlantic Sturgeon, New York Bight DPS	E - 77 FR 5880	81 FR 35701 (Proposed)	-- --
Atlantic Sturgeon, Chesapeake Bay DPS	E - 77 FR 5880	81 FR 35701 (Proposed)	-- --
Atlantic Sturgeon, Carolina DPS	E – 77 FR 5914	81 FR 36077 (Proposed)	-- --
Atlantic Sturgeon, South Atlantic DPS	E – 77 FR 5914	81 FR 36077 (Proposed)	-- --

4.1 Species and Critical Habitat Not Considered Further in this Opinion

The directed research would target Atlantic and shortnose sturgeon. ESA-listed species occurring within the action area that are either not likely to be exposed to the proposed research, or are not likely to be adversely affected, include: green turtle *Chelonia mydas)*, Kemp's Ridley turtle (*Lepidochelys kempii)*, and loggerhead turtle (*Caretta caretta)*. The Delaware River Estuary and Chesapeake Bay do not encompass designated critical habitat of ESA-listed species described above.

The authorized activities would include netting in tidally mixed freshwater areas in the Delaware River between approximately rkm 79 to 215 and throughout the Chesapeake Bay. Although sea turtles and listed marine mammals occur within both of the action areas, researchers have not encountered any in the described research area while sampling for Atlantic or shortnose sturgeon under previous permits in the Delaware River and Chesapeake Bay. Since target species sampling (i.e., gill netting) would occur in habitats not known to be occupied by ESA-listed sea turtles or marine mammals, these species are not expected to be entangled in nets. When using larger mesh gill/trammel nets, the researchers will drift fish and employ continuous monitoring of nets, limiting potential mortality or harm to turtles. Additionally, a visual watch will be maintained during all boating activities. This is expected avoid striking any protected species during research activities.

Although the Permits Division does not anticipate impacts to sea turtles or marine mammals, the permit contains conditions provided by sea turtle and marine mammal specialists in order to avoid interactions and/or impacts (see Permits No. 19331 and No. 19642). These guidelines include: 1) maintaining a visual watch during all boating activities for protected species; 2) continual (varying on location and net type), complete, and thorough visual net checks; 3) delaying deployment or early retrieval of nets if other listed species are found within a 100 ft safety zone radius of the netting area (this includes a thirty minute clearance requirement after the last sighting within the safety zone). Because the researchers will implement the guidelines outlined above to minimize the likelihood of affecting non-target species and based on the researcher’s history of never encountering non-target ESA-listed species in previous research in the same area, the proposed research activities are extremely unlikely to affect non-target ESA-listed species. The likelihood of affecting non-target ESA-listed species is discountable. Therefore, the proposed research activities are not likely to adversely affect ESA-listed sea turtles or marine mammals and will not be considered further in this opinion.

Critical habitat has been proposed for the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs (81 FR 35701), and the Carolina and South Atlantic DPSs (81 FR 36077) Atlantic sturgeon. Aquatic habitat units in rivers throughout the range of Atlantic sturgeon are proposed for designation, including Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida.

A key conservation objective for the proposed designation is to protect spawning habitat, promote successful reproduction and recruitment of Atlantic sturgeon into the marine environment. To that end, the proposed Rules identified the following essential physical features:

- Hard bottom substrate in low salinity waters for Atlantic sturgeon eggs and early life stages,
- Juvenile foraging habitat with a gradual downstream salinity gradient and soft substrate,
- Habitat conditions (water depth and absence of physical barriers) that support movement of adults to and from spawning sites, movement of juveniles to appropriate salinity zones

in the river estuary, and staging, resting or holding of subadults or spawning condition adults, and

- Water quality parameters (temperature, salinity, and dissolved oxygen) that support spawning, survival, growth, development and recruitment of larvae, juveniles, and subadults.

Activities that may impact the proposed critical habitat include in-water construction, dredging, bridge, culvert and road projects, hydropower, utility lines, sand and gravel mining, and activities requiring National Pollutant Discharge Elimination System permits.

The proposed action could take place within the proposed units of critical habitat for Chesapeake Bay DPS and New York Bight DPS Atlantic sturgeon. The proposed activity involves boating, capture and sampling of ESA-listed Atlantic and shortnose sturgeon, which would not alter any of these essential features. The proposed action would not destroy or adversely modify the proposed designated critical habitat for Chesapeake Bay and New York Bight DPS Atlantic sturgeon, and is not considered further in this opinion.

4.2 Species Considered Further in this Opinion

Based on the anticipated exposure and response of species to stressors, we identified the endangered and threatened species that are likely to be adversely affected by the proposed research activities. This section of the opinion consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the proposed research activities. In each narrative, we present a summary of information on each species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

4.2.1 Shortnose sturgeon

Sturgeon are among the most primitive of the bony fishes. Their body surface contains five rows of bony plates, or "scutes." They are typically large, long-lived fish that inhabit a great diversity of riverine habitat, from the fast-moving freshwater riverine environment downstream to the offshore marine environment of the continental shelf.

The shortnose sturgeon *Acipenser brevirostrum* (Lesueur 1818), is the smallest of the three sturgeon species that occur in eastern North America; they grow up to 4.7 feet (1.4 m) and weigh up to 50.7 pounds (23 kg). Their growth rate and maximum size vary, with the fastest growth occurring among southern populations. Female sturgeon can live up to 67 years, but males seldom exceed 30 years of age. Thus, the ratio of females to males among young adults is 1:1, but changes to 4:1 for fish larger than 3 feet (90 cm).

4.2.1.1 Species Description, Distribution and Population Structure

The shortnose sturgeon is endangered range-wide and occurs along the Atlantic Coast of North America, from the St. John River in Canada to the St. Johns River in Florida. Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The Shortnose Sturgeon Recovery Plan (NMFS 1998b) describes 19 shortnose sturgeon populations that exist in the wild (Table 9), but are not formally recognized by NMFS as DPSs under the ESA. Two additional geographically separate 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 individual shortnose sturgeon move between some of these populations each generation (Quattro et al. 2002; Wirgin et al. 2005; Wirgin et al. 2010) .

Table 9. Populations defined in the Shortnose Sturgeon Recover Plan (NMFS 1998b).

Populations:	**Rivers Inhabited by Shortnose Sturgeon**
Saint John	Saint John River (New Brunswick, Canada)
Penobscot	Penobscot River (Maine)
Kennebec System	Sheepscot, Kennebec, and Androscoggin Rivers (Maine)
Merrimack	Merrimack River (Massachusetts)
Connecticut	Connecticut River (Massachusetts and Connecticut)
Hudson	Hudson River (New York)
Delaware	Delaware River (New Jersey, Delaware. Pennsylvania)
Chesapeake Bay	Chesapeake Bay, Potomac River (Maryland and Virginia)
Cape Fear	Cape Fear River (North Carolina)
Winyah Bay	Waccamaw, Pee Dee and Black Rivers (South Carolina,
Santee	Santee River (South Carolina)
Cooper	Cooper River (South Carolina)
"ACE" Basin	Ashepoo, Combahee and Edisto Rivers (South Carolina)
Savannah	Savannah River (South Carolina, Georgia), and hatchery
Ogeechee	Ogeechee River (Georgia)
Altamaha	Altamaha (Georgia)
Satilla	Satilla River (Georgia)
St. Marys	St. Marys River (Florida)
St. Johns	St. Johns River (Florida)

Population sizes vary across the species' range (Table 10). Both regional population and metapopulation structures may exist according to genetic analyses and dispersal and migration patterns (King et al. 2014a; Wirgin et al. 2010). The distribution of shortnose sturgeon is disjunct across their range, with northern populations separated from southern populations by a distance of about 400 km near their geographic center in Virginia. 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 one to 10 individuals per generation, with the highest rates of exchange occurring between the Ogeechee and Altamaha Rivers (Wirgin et al. 2005). Additionally, these researchers concluded that genetic components of sturgeon in rivers separated by more than 400 km were connected by very little migration while rivers separated by less than 20 km (such as the rivers flowing into coastal South Carolina) would experience high migration rates (Wirgin et al. 2005). 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; Wirgin et al. 2010) or remnants of a population in the Potomac River. Rogers and Weber (1995), Kahnle et al. (1998), Collins et al. (2000a) concluded that shortnose sturgeon were extirpated from the St. Johns River in Florida and the St. Marys River along the Florida and Georgia border. However, 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 extirpated in Georgia's Satilla River. However, researchers from the University of Georgia (Fritts and Peterson 2011) documented and tagged a small number of shortnose sturgeon in the Satilla (11 individuals) and St. Marys Rivers (1 individual) between 2008 and 2010. None of these fish were recaptured during the study. Water quality data for the St. Marys River indicated that juvenile sturgeon habitat was sub-optimal throughout the summer, with water temperatures above 30°C, and dissolved oxygen concentrations characteristically below 3.0 mg/L. Fritts and Peterson (2011) concluded that growth and survival of juvenile shortnose sturgeon were likely hindered during summer months by hypoxic conditions in critical nursery habitats in these southernmost rivers.

Table 10. Shortnose sturgeon population estimates

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)
		2005	4,836		(Li et al. 2007)
		2009/2011	3,852-5,222		(Usvyatsov et al. 2012)
Penobscot River	ME	2006-2007	1,049	673-6,939	(Zydlewski 2009) (Fernandes et al. 2008)
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		7,200	5,000-10,800	(Squiers et al. 1993)
Merrimack River	MA	1989-1990	33	18-89	(NMFS 1998b)
Connecticut River	MA, CT	2003	-	1,500-1,800	(CDEP 2003)
		1998-2002	-	1,042-1,580	(Savoy 2004)
Above Holyoke Dam	MA	1976-1977	515	317-898	(NMFS 1998b; Taubert 1980a)
		1977-1978	370	235-623	
		1976-1978	714	280-2,856	
		1976-1978	297	267-618	
Below Holyoke Dam	MA, CT	1988-1993	895	799-1,018	(Savoy and Shake 1992) (NMFS 1998b)
Hudson River	NY	1980	30,311		(Dovel 1979; NMFS 1998b)
		1995	38,000	26,427-55,072	(Bain et al. 1995; NMFS 1998b)
		1997	61,000	52,898-72,191	(Bain et al. 2000b)
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 Herron 2003)
Chesapeake Bay	MD, VA	no data	-	-	
Potomac River	MD, VA	no data	-	-	
Neuse River	NC	2001-2002	extirpated		(Oakley 2003; Oakley and Hightower 2007)
Cape Fear River	NC	1997	>100		(Kynard 1997) (NMFS 1998b)
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	-	-	
Cooper River	SC	1996-1998	220 caught	87-301	(Cooke et al. 2004)
ACE Basin	SC	no data	-	-	
Savannah River	SC, GA		2,000		SSSRT 2010
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	
		2007-2011		200-450	(Peterson and Farrae 2011)

Population/ Subpopulation	Distribution	Datum	Estimate	Confidence Interval	Source
Altamaha River	GA	1988	2,862	1,069-4,226	(NMFS 1998b)
		1990	798	645-1,045	
		1993	468	315-903	
		2003-2005	6,320	4,387-9,249	(DeVries 2006)
		2006	5,551	2,804-11,304	(Peterson and Bednarski 2013)
		2009	1,206	566-2,759	
Satilla River	GA		?	-	(Kahnle et al. 1998)
		2008-2010	11 caught		(Fritts and Peterson 2011)
Saint Mary's River	GA/FL		?	-	(Kahnle et al. 1998; Rogers and Weber 1994)
		2008-2010	1 caught		(Fritts and Peterson 2011)
Saint Johns River	FL	2002	1 caught	-	(FFWCC 2007)

In addition to wild populations, several captive individuals and populations of shortnose sturgeon exist (Table 11). These captive individuals and populations have been developed from for educational purposes for research, enhancement, educational, and public display purposes.

Table 11. Examples of populations and individuals currently reared or held in captivity.

Permit No.	Location	Organization	Species	Exp. Date
16229	North Carolina Zoological Park	North Carolina Zoological Park	Shortnose Sturgeon (Adult)	2016-12-16
16266	Virginia Living Museum	Virginia Living Museum	Shortnose Sturgeon (Adult)	2016-06-20
16291	Maritime Aquarium	Maritime Aquarium at Norwalk	Shortnose Sturgeon (Adult)	2016-06-20
16548	Springfield Science Museum	Springfield Science Museum	Shortnose Sturgeon (Adult/ Juvenile)	2016-12-16
16549	Connecticut River and Gulf of Maine rivers	USGS, Biological Resources	Shortnose Sturgeon (Egg/ Larvae)	2018-04-08
17364	Northeast Fishery Center in Lamar, PA	U.S. Fish and Wildlife Service	Atlantic Sturgeon; Chesapeake Bay (Adult); New York Bight (Adult/ Juvenile; Egg/ Larvae); Rangewide (Adult; Egg/ Larvae; Juvenile)	2018-03-13
17367	Warm Springs Regional Fisheries Center	U.S. Fish and Wildlife Service	Shortnose Sturgeon (Juvenile); Atlantic Sturgeon - rangewide (Juvenile)	2018-02-28

4.2.1.2 Habitat Use and Movement

Shortnose sturgeon are anadromous, inhabiting large coastal rivers or nearshore estuaries with river systems. This species migrates periodically into fresh water areas to spawn but regularly enter saltwater habitats during their life cycle (Kieffer and Kynard 1993; SSSRT 2010).

Adult shortnose sturgeon typically prefer deep downstream areas with vegetated bottoms and soft substrates. During the summer and winter months, the adults occur primarily in freshwater tidally influenced river reaches; therefore, they often occupy only a few short reaches of a river's entire length (Buckley and Kynard 1985b). In the southern end of their range during the summer, adult and juvenile shortnose sturgeon congregate in cool, deep, areas of rivers to seek refuge from high temperatures (Flournoy et al. 1992; Rogers and Weber 1994; Rogers and Weber 1995; Weber 1996). Older juveniles or subadults tend to move downstream in the fall and winter as water temperatures decline and the salt wedge recedes. In the spring and summer, they move upstream and feed mostly in freshwater reaches; however, these movements usually occur above the saltwater/freshwater river interface (Dadswell et al. 1984; Hall et al. 1991). Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981), but remain within freshwater habitats.

Shortnose sturgeon have been found in waters with temperatures as low as 2 to 3ºC (Dadswell et al. 1984) and as high as 34ºC (Heidt et al. 1978). However, temperatures above 28ºC are thought to adversely affect shortnose sturgeon (Kynard 1997). In the Altamaha River, temperatures of 28 to 30ºC during summer months create unsuitable conditions and shortnose sturgeon are found in deep cool water refuges. Dissolved oxygen also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low dissolved oxygen versus the ability to withstand higher temperatures with elevated dissolved oxygen (Kahn and Mohead 2010; Niklitschek 2001).

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6 m is necessary for adults to swim unimpeded. This species is known to occur at depths of up to 30 m, but are generally found in waters less than 20 m (Dadswell 1979; Dadswell et al. 1984). Shortnose sturgeon exhibit tolerance to a wide range of salinities; documented in freshwater (Taubert 1980a; Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yelverton 1973). McCleave et al. (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10 ppt within a two hour period. The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1997). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989a).

While shortnose sturgeon do not undertake the long marine migrations seen in Atlantic sturgeon, telemetry data indicates that shortnose sturgeon do make localized coastal migrations (Dionne et al. 2013). This is particularly true within certain areas such as the Gulf of Maine (GOM) and among rivers in the Southeast. Inter-basin movements have been documented among rivers within the GOM (e.g., travel greater than 130 km; Dionne et al. 2013) and between the GOM and the Merrimack, between the Connecticut and Hudson rivers, the Delaware River and Chesapeake Bay, and among the rivers in the Southeast (Dionne et al. 2013; Fernandes et al. 2010; Finney et al. 2006; Welsh et al. 2002).

Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in the spring, and localized, wandering movements in the summer and winter (Buckley and Kynard 1985a; Dadswell et al. 1984; O'Herron II et al. 1993). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding and overwintering activities. In the spring, as water temperatures reach between 7 and 9.7ºC, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998b).

4.2.1.3 Age and Growth

The shortnose sturgeon is relatively slow growing, late maturing and long-lived, attaining lengths of 14 to 30 cm in the first year and maturity at approximately 45 to 55 cm FL depending on location. They appear to live longer in the northern portion of their range than those in the southern extent (Gilbert 1989a). The maximum age reported for female shortnose sturgeon include: 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 1984). Female shortnose sturgeon appear to outlive and outgrow the males (COSEWIC 2005; Dadswell et al. 1984; Gilbert 1989a).

This species also exhibits sexually dimorphic growth patterns across latitudes (Dadswell 1984). In the north, males reach maturity at 5 to 11 years, while females mature between 7 and 18 years. Shortnose sturgeon in southern rivers grow faster but mature at younger ages (two to five years for males and four to five for females), but attain smaller maximum sizes than those in the north that grow throughout their lifespan (Dadswell 1984). The land-locked shortnose sturgeon population located upstream of Holyoke Dam (rkm 140) of the Connecticut River has the slowest growth rate of any shortnose sturgeon surveyed (Taubert 1980a). The maximum recorded size of shortnose sturgeon was collected from the Saint John River, Canada, measuring 143 cm total length and weighed 23 kg (Dadswell 1984). Collections from 1998 through 2002 report maximum size in the Saint John River as 140.5 cm total length (M. Litvak, University of New Brunswick, pers. comm. 2009).

4.2.1.4 Maturity and Spawning

Once males begin spawning, one to two years after reaching sexual maturity, they will spawn every other year or annually depending on the river they inhabit (Dadswell 1979; Kieffer and

Kynard 1996; NMFS 1998b). Age at first spawning for females is around five years post-maturation (Dadswell 1979), with spawning occurring approximately every three to five years (Dadswell 1979). Spawning is estimated to last from a few days to several weeks, starting in late winter/early spring (southern rivers) to mid to late spring (northern rivers). Long-lived species that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure enough juveniles survive to reproductive maturity and reproduce enough times to maintain stable population sizes (Crouse 1999; Crouse et al. 1987; Crowder et al. 1994).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996), typically at the farthest upstream reach of the river, if access is permitted (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers) (NMFS 1998b). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1 km reach below the Brunswick Dam and (Kieffer and Kynard 1996) found that adults spawned within a 2 km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell 1979; NMFS 1998b). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 to 15ºC, and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell 1979; Hall et al. 1991; Kieffer and Kynard 1996; NMFS 1998b). For northern shortnose sturgeon, the temperature range for spawning is 6.5 to 18.0ºC (Kieffer and Kynard 2012). Kynard et al. (2011) demonstrated the ability to spawn sturgeon in artificial, semi-natural streams for conservation purposes.

Adult shortnose sturgeon typically leave the spawning grounds shortly afterwards. Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge.

Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell 1984). Furthermore, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998b). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female and a mean of 11,568 eggs/kg body weight (Dadswell 1984).

At hatching, shortnose sturgeon are 7 to 11 mm long and resemble tadpoles (Buckley and Kynard 1981). In nine to twelve days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15 mm total length (Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20 mm total length. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked seven to twelve days after hatching in comparison to Savannah River larvae that had longer dispersal rates with multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007). Snyder (1988) and Parker

(2007) considered individuals to be juvenile when they reached 57 mm total length. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while Savannah River individuals made this transition on day 41 and 42 (Parker 2007).

4.2.1.5 Feeding

Shortnose sturgeon are benthic omnivores that feed on crustaceans, insect larvae, worms, mollusks (Collins et al. 2008; Moser and Ross 1995; NMFS 1998b; Savoy and Benway 2004), oligochaete worms (Dadswell 1979 in NMFS 1998; Vladykov and Greely 1963), and feed off plant surfaces and on fish bait (Dadswell et al. 1984). Subadults feed indiscriminately, consuming aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Bain 1997; Carlson and Simpson 1987; Dadswell 1979). In one study, young of the year juveniles' stomach contents included amphipods, corresponding to organisms found within the channel environment (Carlson and Simpson 1987).

4.2.1.6 Status and Trends of Shortnose Sturgeon

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001) pursuant to the Endangered Species Preservation Act of 1966 until it was listed as endangered throughout its range in 1974 under the ESA (38 FR 41370). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon were commonly taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon. More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). This species was first listed on the International Union for Conservation of Nature and Natural Resources Red List in 1986 where they remain listed as Vulnerable and facing a high risk of extinction. A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (NMFS 1998b). Critical habitat has not been designated for shortnose sturgeon.

Despite the longevity of individual sturgeon, the viability of sturgeon populations is highly sensitive to increases in juvenile mortality that result in chronic reductions in the number of subadults 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 extinct in the wild or extinct over portions, or the entirety, of their range. Several authors have also demonstrated that sturgeon populations, 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).

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. Relatively low adult mortality rates appear sufficient to maintain the viability of most of these populations, which appear relatively large and stable. However, the southern population is characterized by meta-populations with its center in the Altamaha River system (Peterson and Farrae 2011; Tim King pers. comm., 2011), with genetic differences expressed between river basins.

4.2.1.7 Critical Habitat

Critical habitat has not been designated for shortnose sturgeon.

4.2.1.8 Shortnose Sturgeon in the Action Area – Delaware River

Shortnose sturgeon occur throughout the Delaware River estuary and occasionally enter the nearshore ocean off Delaware Bay (Brundage III and Meadows 1982). Tagging studies by O'Herron II et al. (1993) found that the most heavily used portion of the river appears to be between river mile 118 below Burlington Island and river mile 137 at the Trenton Rapids. In spring, spawning adults migrate up-river in the non-tidal river in freshwater, and are common at least as far upstream as Scudders Falls (rkm 225). According to Dadswell et al. (1984), ripe adults have been captured as far upstream as Lambertville (rkm 240). The farthest upstream confirmed account of a shortnose sturgeon in the Delaware River is from NMFS (1998b).

Shortnose sturgeon appear to be strictly benthic feeders (Dadswell et al. 1984). Adults eat mollusks, insects, crustaceans and small fish. Juveniles eat crustaceans and insects. While shortnose sturgeon forage on a variety of organisms, in the Delaware River, sturgeon primarily feed on the Asiatic river clam (*Corbicula manilensis*). *Corbicula* is widely distributed at all depths in the upper tidal Delaware River, but it is considerably more numerous in the shallows on both sides of the river than in the navigation channels. Foraging is heaviest immediately after spawning in the spring and during the summer and fall, and lighter in the winter (Dadswell et al. 1984).

Hastings et al. (1987) estimated a modified Schnabel estimate of adult shortnose sturgeon in the Delaware River at 12,796 (95 percent confidence interval – 10,228 to 16,367) based on mark recapture data collected during 1981 through 1984. Environmental Research and Consulting, Inc. ((ERC 2006b) later estimated the population at 12,047 to 13,580. A Chapman modification of the Schnabel estimate was used based on mark-recapture data collected from January 1999 through March 2003. Hastings et al. (1987) used Floy T-anchor tags in a tag-and-recapture experiment from 1981 to 1984 to estimate the size of the Delaware River population in the Trenton to Florence reach. Population sizes by three estimation procedures ranged from 6,408 to 14,080 adult sturgeon. These estimates compare favorably with those based upon similar methods in similar river systems. This is the best available information on population size, but because the recruitment and migration rates between the population segment studied and the total population in the river are unknown, model assumptions may have been violated.

Delaware shortnose sturgeon are documented to spawn from late March through early May (H. Brundage, ERC, Inc., personal communication to NMFS, 2008). Spawning occurs primarily between Scudders Falls and the Trenton rapids (rkm approximately 223 to 215) in Mercer County (Hoff 1965; O'Herron II et al. 1993). The capture of early life stages (eggs and larvae) in this region in the spring of 2008 confirms that this area of the river is used for spawning and as a nursery area. Shortnose sturgeon eggs have also been collected upstream of Titusville, New Jersey (rkm 229) in spring 2008. At the beginning of the Trenton Rapids fall line, the river in the nontidal area is relatively shallow (<3 meters in summer), characterized by pools, riffles and rapids (O'Herron II et al. 1993). Substrates in this area are composed primarily of sand, gravel, and cobble, with soft sediments found in areas of weaker currents. Spawning can occur between 8 and 25°C, with most spawning occurring within the 10 to 18°C range. Surveys by ERC, Inc. of early life stages and observations of impingement/entrainment studies, confirmed the presence of shortnose sturgeon larvae and/or eggs between Scudders Falls (rkm 223) and Trenton (rkm 215). Larvae collected at Fairless Hills, Pennsylvania, cogeneration plant (approximately rkm 191), well south of the spawning/rearing area, may have been carried there during a one day flood event. The capture of early life stages (eggs and larvae) in this region in the spring of 2008 confirms that this area of the river is used for spawning and as a nursery area (ERC 2008).

Shortnose sturgeon were found to overwinter in the Roebling (rkm 199), Bordentown (rkm 207), or Trenton reaches from December through March. The channel off Duck Island (rkm 208) is known to be used heavily by overwintering shortnose sturgeon (O'Herron II et al. 1993). Recent acoustic tagging studies indicate the existence of an overwintering area in the lower portion of the river, below Wilmington, DE (ERC 2006a). Wintering adults are normally observed in tight aggregations and movement at this time appears to be minimal. In addition, results from a preliminary tracking study of juvenile shortnose sturgeon suggest that the entire lower Delaware River from Philadelphia (approx. rkm 161) to below Artificial Island (rkm 79) may be utilized as an overwintering area by juvenile shortnose sturgeon (ERC 2007). According to ERC, Inc. (2007), juvenile sturgeon in the Delaware River appear to overwinter in a dispersed fashion rather than in dense aggregations like adults.

Acoustic tagging studies by ERC, Inc. (2006a) indicate that adult shortnose sturgeon demonstrate one of two generalized movement patterns, either making long excursions from the upper to the lower tidal river (Pattern A) or remaining in and utilizing the upper tidal river (Pattern B). Fish with Pattern A movements made long distance excursions, often moving between the upper tidal river and the area of the Chesapeake and Delaware Canal (C&D Canal) (rkm 95) or farther downstream. Movements were often rapid, with one fish swimming 121 kilometers in six days. The long distance excursions often occurred in spring, after the spawning period (likely movement to summer foraging areas), and in early to mid-winter (likely moving to overwintering areas) (ERC 2006a). Most of the tagged shortnose sturgeon occupied known overwintering areas in the Roebling, Bordentown, and Trenton reaches of the upper tidal river during December through March. Three fish, however, appear to have overwintered downriver, below Wilmington (rkm 113), suggesting the existence of an overwintering area in the lower river. Downriver overwintering areas are known to occur in other river systems, but previously were not described in the Delaware River (ERC 2006a). Movement patterns observed in the ERC study indicate some, but not all, of the adult shortnose sturgeon overwintering in the upper tidal Delaware River move to the spawning area in the lower non-tidal river in late March and April (ERC 2006a).

Preliminary tracking studies of juvenile shortnose sturgeon exhibited different winter movement patterns (n=3), indicating that the entire lower Delaware River (Philadelphia to below Artificial Island; approx. rkm 161 to 79) may be utilized for overwintering (ERC 2007). One fish with a tag was active in late spring and summer, showed movement spanning approximately 25 km between Chester and Deepwater Point ranges (rkm 130 to 101), spending much of its time in the vicinity of Marcus Hook (rkm 128; ERC 2007).

Investigations with video equipment by the U.S. Army Corps of Engineers (USACE) in March 2005 (Versar 2005) documented two sturgeon of unknown species at Marcus Hook and 1 sturgeon of unknown species at Tinicum. Gillnetting in these same areas caught only one Atlantic sturgeon and no shortnose sturgeon. Video surveys of the known overwintering area near Newbold documented 61 shortnose sturgeon in approximately one-third of the survey effort. This study supports the conclusion that the vast majority of adult shortnose sturgeon overwinter near Duck and Newbold Island but that a limited number of shortnose sturgeon occur in other downstream areas, including Marcus Hook, during the winter months.

4.2.1.9 Shortnose Sturgeon in the Action Area – Chesapeake Bay

Shortnose sturgeon are known to occur in the Chesapeake Bay system, but they may be transients from the Delaware River via the Chesapeake and Delaware Canal (Skjeveland et al. 2000; SSSRT 2010; Welsh et al. 2002) or remnants of a population in the Potomac River. Shortnose sturgeon historically occurred in the Chesapeake Bay, but prior to 1996, the best available information suggested that the species was either extirpated from the area or present in extremely low numbers. Before 1996, there were only 15 published historic records of shortnose sturgeon in the Chesapeake Bay, and most of these were based on personal observations from the upper Chesapeake Bay during the 1970s and 1980s (Dadswell et al. 1984). From February through November 1997, a Fish and Wildlife Service reward program was in effect for Atlantic sturgeon in Virginia’s major tributaries (James, York, and Rappahannock Rivers). A sturgeon captured from the Rappahannock River in May 1997 was confirmed as a shortnose sturgeon (Spells 1998). On October 22, 2003, an endangered species observer initially reported the capture of one shortnose sturgeon in a sea turtle relocation trawling operation in Thimble Shoals Channel. As of July 2009, participants from the Maryland Atlantic Sturgeon Reward Program reported 82 shortnose sturgeon in the Chesapeake Bay and its tributaries (USWFS 2009). The current population estimate of shortnose sturgeon in the Chesapeake Bay and its tributaries is unknown.

4.2.2 Atlantic sturgeon

The Atlantic sturgeon (Mitchill, 1815) is a long-lived, estuarine dependent, anadromous fish. Atlantic sturgeon can grow to approximately 14 feet (4.3 m) long and can weigh up to 800 pounds (370 kg). They are bluish-black or olive brown dorsally (on their back) with paler sides and a white belly. They have five major rows of dermal "scutes".

Atlantic sturgeon are similar in appearance to shortnose sturgeon, but can be distinguished by their larger size, smaller mouth, different snout shape, and scutes.

4.2.2.1 Species Description, Distribution and Population Structure

The Atlantic sturgeon is a long-lived (approximately 60 years), late maturing, iteroparous, estuarine dependent species (ASSRT 2007; Bigelow and Schroeder 1953a; Dadswell 2006; Mangin 1964; Pikitch et al. 2005; Vladykov and Greely 1963). Atlantic sturgeon are anadromous, spawning in freshwater, but spending most of their subadult and adult life in the marine environment. While intensely studied since the 1970s, many important aspects of Atlantic sturgeon life history are still unknown.

As of 2012, Atlantic sturgeon is considered endangered within four DPSs and threatened within one (Figure 2), as listed below.

- ESA Endangered: New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS
- ESA Threatened: Gulf of Maine DPS

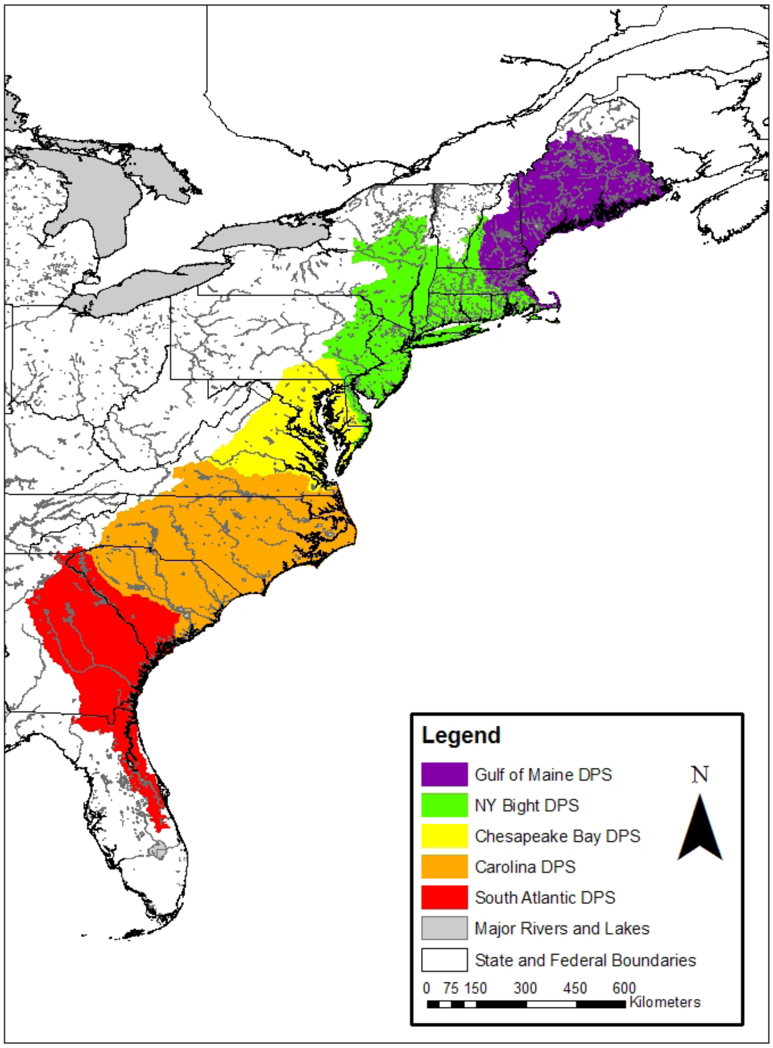

Figure 2. Range and boundaries of the five Atlantic sturgeon DPSs.

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 (ASSRT 2007; Smith and Clugston 1997). This species has also 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, Maine to the Saint Johns River, Florida, of which 35 rivers have been confirmed to have had historical spawning populations. Atlantic sturgeon are currently present in approximately 32 rivers, and spawning occurs in at least 20 of these (ASSRT 2007). Other estuaries along the coast formed by rivers that do not support Atlantic sturgeon spawning populations may still be important rearing habitats.

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19th century when a caviar market was established (ASSRT 2007; Dadswell 2006; Maine State Planning Office 1993; Scott and Crossman 1973; Smith and Clugston 1997; Taub 1990). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware River, and at least 10,000 females for other spawning stocks (Secor 2002; Secor and Waldman 1999).

While there may be other rivers supporting spawning for which definitive evidence has not been obtained, few rivers are known to currently support spawning from Maine to Virginia. The Atlantic sturgeon status review team presented evidence that only five rivers (Kennebec, Androscoggin, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia, where historical records show that there used to be 15 spawning rivers (ASSRT 2007). Hager et al. (2014) recently documented Atlantic sturgeon spawning in the York River.

4.2.2.2 Habitat Use and Movement

Subadult and adult Atlantic sturgeon undertake long marine migrations and utilize habitat up and down the East Coast for rearing, feeding, and (Bain 1997; Dovel and Berggren 1983; Stevenson 1997). These migratory subadults, as well as adults, are normally located in shallow (10 to 50 m) near shore areas dominated by gravel and sand substrates (Stein et al. 2004). Tagging and genetic data indicate that subadult and adult Atlantic sturgeon may travel widely once they emigrate from rivers. Once in marine waters, subadults 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 five 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 (Grunwald et al. 2008).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 m in depth, using coastal bays, sounds, and ocean waters (Collins and Smith 1997; Dovel and Berggren 1983; Dunton et al. 2010; Erickson et al. 2011; Laney et al. 2007; Murawski and Pacheco 1977; Savoy and Pacileo 2003; Smith 1985; Stein et al. 2004; Vladykov and Greely 1963; Welsh et al. 2002; Wirgin and King 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 m during the winter and spring, and in the northern portion at depths less than 20 m in the summer and fall (Erickson et al. 2011).

Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC 2009) found a similar movement pattern for juvenile Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters, where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was reported from tag returns reported in the fall, with the majority of these tag returns from relatively shallow nearshore fisheries, with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (ASSRT 2007; Dadswell 2006; Dadswell et al. 1984; Dovel and Berggren 1983; Eyler et al. 2004; Johnson et al. 1997; Kynard et al. 2000; Laney et al. 2007; Rochard et al. 1997; Stein et al. 2004; Wehrell 2005). These sites may be used as foraging sites and/or thermal refuge.

4.2.2.3 Age and Growth

Atlantic sturgeon can grow to over 4 m, weighing 800 lbs (Pikitch et al. 2005). They can reach 60 years of age (Mangin 1964); however, this should be considered an approximation because modern age validation studies demonstrated that ages cannot be reliably estimated after 15 to 20 years (Stevenson and Secor 1999). The average age at which 50 percent of maximum lifetime egg production is achieved estimated to be 29 years, approximately three to 10 times longer than for other bony fish species examined (Boreman 1997). Dunton et al. (2016) estimated age classes for 742 Atlantic sturgeon from the New York DPS, ranging from 2 to 35 years of age, with 84 percent of these fish less than 12 years old. 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 (Collins et al. 2000b; Schueller and Peterson 2010; Smith 1985) and three to five years for females (Schueller and Peterson 2010; Stevenson and Secor 1999; Vladykov and Greely 1963). Fecundity of Atlantic sturgeon has been correlated with age and body size (ranging from 400,000 to 8 million eggs) (Dadswell 2006; Smith et al. 1982; Van Eenennaam et al. 1996).

4.2.2.4 Maturity and Spawning

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; and (3) fully mature females attain a larger size (i.e. length) than fully mature males. The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greely 1963). Dadswell (2006) observed seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Dadswell 2006; Smith et al. 1982; Van Eenennaam et al. 1996; Van Eenennaam and Doroshov 1998). The lengths of Atlantic sturgeon caught since the mid to late 20th century have typically been under three meters (ASSRT 2007; Caron et al. 2002; Collins et al. 2000b; Dadswell 2006; DFO 2011; Kahnle et al. 2007; Scott and Scott 1988; Smith et al. 1982; Smith and Dingley 1984; Smith 1985; Vladykov and Greely 1963; Young et al. 1988).

While females are prolific, with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of two to five years (Dadswell 2006; Smith et al. 1982; Stevenson and Secor 1999; Van Eenennaam et al. 1996; Van Eenennaam and Doroshov 1998; Vladykov and Greely 1963). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman 1997). Males exhibit spawning periodicity of one to five years (Caron et al. 2002; Collins et al. 2000b; Smith 1985). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC 2009). Spawning migrations generally occur February to March in southern systems, April-May in Mid-Atlantic systems, and May to July in Canadian systems (Bain 1997; Caron et al. 2002; Murawski and Pacheco 1977; Smith 1985; Smith and Clugston 1997). Male sturgeon begin upstream spawning migrations when waters reach approximately 6°C (ASMFC 2009; Dovel and Berggren 1983; Smith et al. 1982; Smith 1985), and remain on the spawning grounds throughout the spawning season (Bain 1997). Females begin spawning migrations when temperatures are closer to 12°to 13°C (Collins et al. 2002b; Dovel and Berggren 1983; Smith 1985), and make rapid spawning migrations upstream then quickly depart after spawning (Bain 1997).

The spawning areas in most U.S. rivers have not been well defined. However, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46 to 76 cm/s and depths range 3 to 27 m (ASMFC 2009; Bain et al. 2000a; Borodin 1925; Caron et al. 2002; Collins et al. 2000b; Crance 1987; Dees 1961; Hatin et al. 2002; Leland 1968; Scott and Crossman 1973; Shirey et al. 1999).

Sturgeon deposit eggs on hard bottom substrate such as cobble, coarse sand, and bedrock (ASMFC 2009; Bain et al. 2000a; Caron et al. 2002; Collins et al. 2000b; Dees 1961; Gilbert 1989b; Mohler 2003; Scott and Crossman 1973; Smith and Clugston 1997), which become adhesive shortly after fertilization (Mohler 2003; Murawski and Pacheco 1977; Van Den Avyle 1984). Egg Incubation time increases as water temperature decreases (Mohler 2003). At temperatures of 20° and 18°C, hatching occurs approximately at 94 and 140 hours, respectively, after egg deposition (ASSRT 2007). The yolksac larval stage is completed in about eight to twelve days, during which time the larvae move downstream to rearing grounds over a six to twelve day period (Kynard and Horgan 2002). During the first half of their migration downstream, movement is limited to night. Larval Atlantic sturgeon (i.e. less than four weeks old, with total lengths less than 30 mm; Van Eenennaam et al. 1996) are assumed to mostly live on or near the bottom and inhabit the same riverine or estuarine areas where they were spawned (ASMFC 2009; Bain et al. 2000a; Kynard and Horgan 2002; Theodore et al. 1980). 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. Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Haley 1999; Hatin et al. 2007; McCord et al. 2007; Munro et al. 2007) while older fish are more salt-tolerant and occur in both high salinity and low salinity waters (Collins et al. 2000b). Juvenile sturgeon continue to move further downstream into brackish waters, and will remain in their natal estuary for months to years before emigrating to open ocean as subadults (ASSRT 2007; Dadswell 2006; Dovel and Berggren 1983; Holland and Yelverton 1973; Waldman et al. 1996).

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 to March in southern systems, April to May in mid-Atlantic systems, and May to July in Canadian systems (Bain 1997; Kahnle et al. 1998; Smith 1985; Smith and Clugston 1997). Some rivers may also support a fall spawning migration. For example, Hager et al. (2014) documented fall spawning of Atlantic sturgeon in the York River system. In the Satilla River, Georgia, genetic analyses by Fritts et al. (2016) of river-resident Atlantic sturgeon suggest that juveniles from the 2008 cohort were genetically distinct from other South Atlantic DPS populations.

4.2.2.5 Feeding

Atlantic sturgeon are bottom feeders that suck food into a ventral protruding mouth (Bigelow and Schroeder 1953b). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder 1953b). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (ASSRT 2007; Bigelow and Schroeder 1953b; Guilbard et al. 2007; Savoy 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (ASSRT 2007; Bigelow and Schroeder 1953b; Guilbard et al. 2007).

4.2.2.6 Status and Trends of Atlantic Sturgeon

On February 6, 2012, four Atlantic sturgeon DPSs were listed as endangered and one as threatened on under the ESA (77 FR 5880, 77 FR 5914). The Chesapeake Bay, New York Bight, Carolina, and South Atlantic populations of Atlantic sturgeon are listed as endangered, while the Gulf of Maine population is listed as threatened. This species was last assessed and listed by the International Union for Conservation of Nature Red List as Near Threatened in 2006, but was formally listed as Lower Risk/ Near Threatened in 1996 and Vulnerable in 1990.

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 (Armstrong and Hightower 2002). A major fishery for this species did not exist until 1870 when a caviar market was established (Smith and Clugston

1997). Record landings were reported in 1890, where over 3,350 metric tons (mt) of Atlantic sturgeon were landed from coastal rivers along the Atlantic Coast (Secor and Waldman 1999; Smith and Clugston 1997). Ten years after peak landings, the fishery collapsed in 1901, when less than 10 percent (295 mt) of its 1890 peak landings were reported. The landings continued to decline to about five percent of the peak until 1920. During the 1950s, the remaining fishery switched to targeting sturgeon for flesh, rather than caviar. Between 1920 and 1998, the harvest level remained very low due to small remnant populations. The majority of these landings (75 percent) were dominated by the Delaware River fishery, which presumably supported the largest population along the Atlantic Coast (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, a coast-wide fishing moratorium was imposed for 20-40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (ASMFC 1998).

At the time of the Atlantic sturgeon ESA listings, there were no existing published population abundance estimates for any of the currently known spawning stocks or five DPSs. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985 to 1995 (Kahnle et al. 2007). Peterson et al. (2008) reported that approximately 324 and 386 adults per year returned to the Altamaha River in 2004 and 2005, respectively.

Since age-1 and age-2 juveniles are restricted to their natal rivers, measuring juvenile Atlantic sturgeon abundance may improve efforts to determine the status of Atlantic sturgeon populations (Bain et al. 1999; Dovel and Berggren 1983). 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 age-2 Atlantic sturgeon population densities in the Altamaha River, Georgia, ranged from 1,000 to 2,000 individuals over a 4 year period from 2004 to 2007.

The Atlantic sturgeon status review team presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT 2007). Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NMFS Northeast Fishery Science Center (NEFSC) developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (Kocik et al. 2013a). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance (Table 13). The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the USFWS sturgeon tagging database (e.g., USFWS 2009), and federal fishery discard estimates from 2006 to 2010 to produce a virtual population.

In addition to the ASPI, a population abundance estimate was derived from the 2007 to 2012 Northeast Area Monitoring and Assessment Program (NEAMAP) trawl surveys from Cape Cod, Massachusetts to Cape Hatteras, North Carolina. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations in nearshore waters at depths up to 18.3 m during the fall and spring. Both models are further described in Table 12.

Table 12. Description of the ASPI model and NEAMAP survey based area estimate method for estimating Atlantic sturgeon abundance.

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

Table 13. Modeled results of estimated Atlantic sturgeon abundance from ASPI and NEAMAP.

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

The information from the NEAMAP survey can be used to calculate minimum swept area population estimates within the strata swept by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 14). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e., net efficiency) 100 percent of the sturgeon in the water column along the tow path and that all sturgeon are within the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100 percent will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100 percent are common for most species. The ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, but is certainly greater than one (i.e. the NEAMAP survey does not survey 100 percent of the Atlantic sturgeon habitat).

Table 14. Annual minimum swept area estimates for Atlantic sturgeon during the spring and fall from the Northeast Area Monitoring and Assessment Program survey. Estimates assume 100 percent net efficiencies. Estimates provided by Dr. Chris Bonzek, Virginia Institute of Marine Science (VMS).

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

The available data do not support estimation of true catchability (i.e., net efficiency X availability) of the NEAMAP trawl survey for Atlantic sturgeon. Thus, the NEAMAP swept area biomass estimates were produced and presented in Kocik et al. (2013a) for catchabilities from 5 to 100 percent. In estimating the efficiency of the sampling net, we consider the likelihood that an Atlantic sturgeon in the survey area is likely to be captured by the trawl. Assuming the NEAMAP surveys have been 100 percent efficient would require the unlikely assumption that the survey gear captures all Atlantic sturgeon within the path of the trawl and all sturgeon are within the sampling area of the NEAMAP survey. In estimating the fraction of the Atlantic sturgeon population within the sampling area of the NEAMAP, we consider that the NEAMAP-based estimates do not include young of the year fish and juveniles in the rivers where the NEAMAP survey does not sample. Additionally, although the NEAMAP surveys are not conducted in the Gulf of Maine or south of Cape Hatteras, NC, they are conducted within the preferred depth ranges of subadult and adult Atlantic sturgeon in the sampling range. NEAMAP surveys take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. Therefore, the NEAMAP estimates are minimum estimates of the ocean population of Atlantic sturgeon, but are based on sampling in a large portion of the marine range, of the five DPSs, in known sturgeon coastal migration areas during times that sturgeon are expected to be migrating north and south.

Based on this methodology, we considered that the NEAMAP samples an area utilized by Atlantic sturgeon, but does not sample all the locations and times where Atlantic sturgeon are present, and the trawl net captures some, but likely not all, of the Atlantic sturgeon present in the sampling area. Therefore, we assumed that net efficiency and the fraction of the population exposed to the NEAMAP survey in combination result in a 50 percent catchability. The 50 percent catchability assumption seems to reasonably account for the robust, yet incomplete spatio-temporal sampling of the Atlantic sturgeon and the documented high rates of encounter with NEAMAP survey gear and Atlantic sturgeon.

The ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey (see Table 13). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the USFWS sturgeon tagging database and federal fishery discard estimates from 2006 to 2010 to produce a virtual population estimate. The NEAMAP estimate, in contrast, does not depend on as many assumptions.

For the purposes of this opinion, we consider the NEAMAP estimate of ocean population abundance resulting from the 50 percent catchability rate (67,776 individuals; Table 13), as the best available information on the number of subadult and adult Atlantic sturgeon in the ocean. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults. Additionally, we can estimate that 10.7 percent of this population abundance(calculated from Table 2 of Kocik et al. 2013a) is comprised of adults, or individuals greater than 150 cm. We then considered an estimate from a mixed stock analysis of the New York Bight DPS of Atlantic sturgeon to encompass 54.6 percent subadult and adult individuals and 20.6 percent of Chesapeake Bay DPS (See Table 2 in Wirgin et al. 2015a).

The ASMFC has initiated a new stock assessment with the goal of completing it in 2017. NMFS will be partnering with them to conduct the stock assessment, and the ocean population abundance estimates produced by the NEFSC will be shared with the stock assessment committee for consideration in the stock assessment.

4.2.2.7 Atlantic Sturgeon New York Bight DPS

The New York Bight DPS includes all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (ASSRT 2007; Murawski and Pacheco 1977; Secor and Waldman 1999). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Taunton River (ASSRT 2007). In June 2014, several presumed age-0 Atlantic sturgeon were captured in the Connecticut River (T. Savoy, CT DEEP, pers. comm. to NMFS). These captures represent the only contemporary records of possible natal Atlantic sturgeon in the Connecticut River. Capture of age-0 Atlantic sturgeon strongly suggests that spawning is occurring in that river (T. Savoy, Connecticut Department of Environmental

Protection, pers. comm. to NMFS; CDEP 2014). Genetic analysis of tissues collected from these individuals is not yet available and will help to determine if these individuals represent a unique Connecticut River Atlantic sturgeon spawning population. The capture of these individuals follows the documentation of a dead adult Atlantic sturgeon in the river in May 2014. Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007; Savoy 2007; Wirgin and King 2011).

While genetic testing can differentiate between individuals originating from the Hudson or Delaware River, the available information suggests that the straying rate is high between these rivers. Some of the impact from the threats that contributed to the decline of the New York Bight DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act. In addition, there have been reductions in fishing effort in state and federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the New York Bight DPS.

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (ASMFC 2009; Stein et al. 2004). Current available estimates indicate that at least 4 percent of adults may be killed as a result of bycatch in fisheries authorized under Northeast FMPs. Based on mixed stock analysis results presented by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid Atlantic Bight region were sturgeon from the New York Bight DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1 to 2 percent were from the New York Bight DPS.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks further upstream passage; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. Connectivity may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the New York Bight region is currently unknown.

New York Bight DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Hudson and Delaware over the past decades (Adkins 2008; Lichter et al. 2006). Both the Hudson and Delaware rivers, as well as other rivers in the New York Bight region, were heavily polluted in the past from industrial and sanitary sewer discharges. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

Vessel strikes occur in the Delaware River. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS. Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (ASMFC 2009; Boreman 1997; Brown and Murphy 2010; Kahnle et al. 2007). NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.2.2.8 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay DPS includes all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e., dams) are located upriver of where spawning is expected to have historically occurred (ASSRT 2007). Spawning occurs in the James River and recently was confirmed in the Pamunkey River (a tributary to the York River) (ASSRT 2007; Greene et al. 2009; Hager et al. 2014; Kahn et al. 2014). The presence of adult sturgeon suggests that spawning may also occur in Marshyhope Creek (a tributary to the Nanticoke River in Maryland). Investigations of spawning are also ongoing in the Mattaponi River where adult sturgeon have been observed. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (ASSRT 2007; Grunwald et al. 2008; Vladykov and Greely 1963; Wirgin et al. 2007).

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

Hudson River (Young et al. 1988). Therefore, age at maturity for Atlantic sturgeon of the Chesapeake Bay DPS likely falls within these values.

NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.2.2.9 ***Carolina DPS of Atlantic sturgeon***

The Carolina DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) from Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. Sturgeon are commonly captured 40 miles (64 km) offshore (D. Fox, DSU, pers. comm. to NMFS). Records providing fishery bycatch data by depth show the vast majority of Atlantic sturgeon bycatch via gillnets is observed in waters less than 50 m deep (ASMFC and Committee 2007; Stein et al. 2004), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms.

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. Spawning was determined to occur if young-of-the-year (YOY) were observed, or mature adults were present, in freshwater portions of a system (ASSRT 2007). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. There may also be spawning populations in the Neuse, Santee and Cooper Rivers, though uncertain. Historically, both the Sampit and Ashley Rivers were documented to have spawning populations at one time. However, the spawning population in the Sampit River is believed to be extirpated and the current status of the spawning population in the Ashley River is unknown. Both rivers may be used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems utilized by the Carolina DPS for specific life functions, such as spawning, nursery habitat, and foraging. However, fish from the Carolina DPS likely use other river systems than those listed here for their specific life functions.

The riverine spawning habitat of the Carolina DPS occurs within the Mid-Atlantic Coastal Plain ecoregion, which includes bottomland hardwood forests, swamps, and some of the world’s most active coastal dunes, sounds, and estuaries. Natural fires, floods, and storms are so dominant in this region that the landscape changes very quickly. Rivers routinely change their courses and emerge from their banks. The primary threats to biological diversity in the Mid-Atlantic Coastal Plain, as listed by The Nature Conservancy are: global climate change and rising sea level; altered surface hydrology and landform alteration (e.g., flood-control and hydroelectric dams, inter-basin transfers of water, drainage ditches, breached levees, artificial levees, dredged inlets and river channels, beach renourishment, and spoil deposition banks and piles); a regionally receding water table, probably resulting from both over-use and inadequate recharge; fire suppression; land fragmentation, mainly by highway development; land-use conversion (e.g., from forests to timber plantations, farms, golf courses, housing developments, and resorts); the invasion of exotic plants and animals; air and water pollution, mainly from agricultural activities including concentrated animal feed operations; and over-harvesting and poaching of species. Many of the Carolina DPS' spawning rivers, located in the Mid-Coastal Plain, originate in areas of marl. Waters draining calcareous, impervious surface materials such as marl are: (1) likely to be alkaline; (2) dominated by surface run-off; (3) have little groundwater connection; and, (4) are seasonally ephemeral.

Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002)(Secor 2002). Secor (2002) estimated that 8,000 adult females were present in South Carolina during that same time-frame. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS. Currently, the Atlantic sturgeon spawning population in at least one river system within the Carolina DPS has been extirpated, with a potential extirpation in an additional system. The ASSRT estimated the remaining river populations within the DPS to have fewer than 300 spawning adults; this is thought to be a small fraction of historic population sizes (ASSRT 2007).

NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.2.2.10 South Atlantic DPS of Atlantic sturgeon

The South Atlantic DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto Rivers (ACE) Basin southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida. The marine range of Atlantic sturgeon from the South Atlantic DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida.

The riverine spawning habitat of the South Atlantic DPS occurs within the South Atlantic Coastal Plain ecoregion, which includes fall-line sandhills, rolling longleaf pine uplands, wet pine flatwoods, isolated depression wetlands, small streams, large river systems, and estuaries. Other ecological systems in the ecoregion include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. Other ecological systems in the ecoregion include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. The primary threats to biological diversity in the South Atlantic Coastal Plain listed by The Nature Conservancy are intensive silvicultural practices, including conversion of natural forests to highly managed pine monocultures and the clear-cutting of bottomland hardwood forests. Changes in water quality and quantity, caused by hydrologic alterations (impoundments, groundwater withdrawal, and ditching), and point and nonpoint pollution, are threatening the aquatic systems. Development is a growing threat, especially in coastal areas. Agricultural conversion, fire regime alteration, and the introduction of nonnative species are additional threats to the ecoregion's diversity. The South Atlantic DPS' spawning rivers, located in the South Atlantic Coastal Plain, are primarily of two types: brownwater (with headwaters north of the Fall Line, silt-laden) and blackwater (with headwaters in the coastal plain, stained by tannic acids).

Secor (2002) estimated that 8,000 adult females were present in South Carolina prior to 1890. Prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery in Georgia. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in the state prior to 1890. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the South Atlantic DPS. Currently, the Atlantic sturgeon spawning population in at least two river systems within the South Atlantic DPS has been extirpated. The Altamaha River population of Atlantic sturgeon, with an estimated 343 adults spawning annually, is believed to be the largest population in the Southeast, yet is estimated to be only six percent of its historical population size. The ASSRT estimated the abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, to be less than one percent of what they were historically (ASSRT 2007).

NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.2.2.11 Gulf of Maine DPS of Atlantic sturgeon

The ESA Threatened Gulf of Maine DPS includes all anadromous Atlantic sturgeons spawned in watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT 2007). Spawning still occurs in the Kennebec River, and possibly still occurring in the Penobscot River as well. Recent evidence indicates that spawning may also be occurring in the Androscoggin River. During the 2011 spawning season, the Maine Department of Marine Resources captured a larval Atlantic sturgeon below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at river kilometer (rkm) 49 blocked access to 58 percent of Atlantic sturgeon habitat in the river (ASSRT 2007; Oakley 2003). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Kieffer and Kynard 1993). Therefore, the availability of spawning habitat does not appear to be the reason for the lack of observed spawning in the Merrimack River. Studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS as well as likely throughout the entire range (ASSRT 2007; Fernandes et al. 2010).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers from May to July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs from June to July (ASMFC 1998; Colligan et al. 1998). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (i.e., expressing milt) in July 1994 below the (former) Edwards Dam; (2) the capture of 31 adult Atlantic sturgeon from June 15 through July 26,1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least 4 ripe males and 1 ripe female captured on July 26,1980; and, (3) the capture of nine adults during a gillnet survey conducted from 1977 to 1981, the majority of which were captured in July from Merrymeeting Bay and upriver as far as Gardiner, ME (ASSRT 2007; Colligan et al. 1998). The low salinity values for waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

Several threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers and Smith 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers and Smith 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by-catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occur. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein et al. 2004). Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

There are no empirical abundance estimates for the Gulf of Maine DPS. The Atlantic sturgeon SRT (2007) presumed that the Gulf of Maine DPS was comprised of less than 300 spawning adults per year, based on abundance estimates for the Hudson and Altamaha River riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977 to 1981 and 1998 to 2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers 2003). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized, adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies.

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate compared to sink gillnet gear for Atlantic sturgeon caught in the gear (ASSRT 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only eight percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin et al. 2015b).

NMFS has determined that the Gulf of Maine DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for consultations include the past and present impacts of all state, Federal, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR § 402.02). The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of ESA-listed resources in the action area.

The following information summarizes the principal natural and human-caused phenomena in the action area believed to affect the survival and recovery of ESA-listed species in the wild.

5.1 Dams and Water Diversion

Dams are used to impound water for water resource projects such as hydropower generation, irrigation, navigation, flood control, industrial and municipal water supply, and recreation. Dams can have profound effects on diadromous fish species by fragmenting populations, eliminating or impeding access to historic habitat, modifying free-flowing rivers to reservoirs and altering downstream flows and water temperatures. Direct physical damage and mortality can occur to diadromous fish that migrate through the turbines of traditional hydropower facilities or as they attempt to move upstream using fish passage devices. The construction of dams throughout shortnose and Atlantic sturgeon's ranges is probably one of the main factors reducing their reproductive success which, in turn, could be one of the primary reasons for the reduction in population size for these species. However, in the Chesapeake Bay and Delaware River, most of the dams are located upriver of Atlantic and shortnose sturgeon spawning grounds, allowing passage to these habitats (ASSRT 2007).

Although there are dams located on other rivers where other shortnose and Atlantic sturgeon populations are found (e.g., the Holyoke Dam on the Connecticut River), the Delaware River is the longest undammed river east of the Mississippi (DRBC 2009). This is due, in large part, to the National Wild and Scenic (16 U.S.C. 1271 et seq.) designated portions of the river. Historically, dams have been proposed for the Delaware River. Tocks Island Dam was a huge multi-purpose reservoir project proposed for the Delaware River six miles upstream of the Delaware Water Gap. The dam would have created a 40-mile long lake with depths up to 140 feet. Almost 250 billion gallons of water were to be stored behind the dam with ample “dry storage” for floodwaters. The project was to be the U.S. Army Corps of Engineers’ eighth largest U.S. dam project and its largest east of the Mississippi River.

Dams in rivers leading into the Chesapeake Bay may pose water quality threats during flood events. For example, in the Susquehanna River, there have been concerns about the sediments and nutrients building up in the reservoirs behind the Conowingo Dam and other dams. A recent report by the Maryland Department of the Environment and the Army Corps of Engineers stated that the accumulated sediments may not be the primary concern; it is the nutrients from runoff into the Susquehanna River watershed polluting the Chesapeake Bay (USACE 2015).

5.2 Dredging

Many rivers and estuaries within the action area are periodically dredged for flood control or to support commercial and recreational boating. Dredging also aids in construction of infrastructure and in marine mining. Dredging may have adverse impacts on aquatic ecosystems including direct removal/burial of organisms, turbidity, contaminant resuspension, noise/disturbance, alterations due to hydrodynamic regime and physical habitat, and actual loss of riparian (Chytalo 1996; Winger et al. 2000).

Dredges are generally either mechanical or hydraulic. Mechanical dredges are used to scoop or grab bottom substrate and are capable of removing hard-packed materials and debris. Mechanical dredge types are clamshell buckets, endless bucket conveyor, or single backhoe or scoop bucket types. However, these dredge types often have difficulty retaining fine materials in the buckets and do not dredge continuously. Material excavated from mechanical dredging is often loaded onto barges for transport to a designated placement site (Palermo et al. 2008).

Hydraulic dredges are used principally to dredge silt, sand, and small gravel. Hydraulic dredges include cutterhead pipeline dredges and self-propelled hopper dredges. These machines remove material from the bottom by suction, producing slurry of dredged material and water, either pumped directly to a placement site, or in the case of a hopper dredge, into a hopper and later transported to a dredge spoil site. Cutterhead pipeline dredges can excavate most materials including some rock without blasting and can dredge almost continuously (Palermo et al. 2008).

The impacts of dredging operations on sturgeon are often difficult to assess. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge drag arms and impeller pumps (NMFS 1998b). Mechanical dredges have also been documented to lethally take shortnose sturgeon (Dickerson 2006). In addition to direct effects, indirect effects from either mechanical or hydraulic dredging include destruction of benthic feeding areas, disruption of spawning migrations, and deposition of resuspended fine sediments in spawning habitat (NMFS 1998b).

Another critical impact of dredging is the encroachment of low dissolved oxygen and high salinities upriver after channelization (Collins et al. 2001). Adult shortnose sturgeon can tolerate at least short periods of low dissolved oxygen and high salinities, but juveniles are less tolerant of these conditions in laboratory studies. Collins et al. (2001) concluded harbor modifications in the lower Savannah River have altered hydrographic conditions for juvenile sturgeon by extending high salinities and low dissolved oxygen upriver.

In addition to the impacts of dredging noted above, Smith and Clugston (1997) reported that dredging and filling eliminates deep holes, and alters rock substrates. Nellis et al. (2007) documented that dredge spoil drifted 12 km downstream over a 10 year period in the Saint Lawrence River, and that those spoils have significantly less macrobenthic biomass compared to control sites. Using an acoustic trawl survey, researchers found that Atlantic and lake sturgeon were substrate dependent and avoided spoil dumping grounds (McQuinn and Nellis 2007). Similarly, Hatin et al. (2007) tested whether dredging operations affected Atlantic sturgeon behavior by comparing CPUE before and after dredging events in 1999 and 2000. The authors documented a three to seven-fold reduction in Atlantic sturgeon presence after dredging operations began, indicating that sturgeon avoid these areas during operations.

Both the Delaware River and Chesapeake Bay are both important commercial and recreational waterways that require periodic dredging with ESA section 7 consultation (e.g., (NMFS 2012)). The bulk of dredging would be performed by hopper and hydraulic pipeline dredges with a bucket dredge used for rock removal (e.g., in the Marcus Hook area) (USACE 2009).

The deepening of the Delaware River Philadelphia to Trenton Federal Navigation Channel has caused shortnose sturgeon mortality in the past and may have affected shortnose sturgeon distribution and foraging habitat. In mid-March 1996, three subadult shortnose sturgeon were found in a dredge discharge pool on Money Island, near Newbold Island. The dead sturgeon were found on the side of the spill area into which the hydraulic pipeline dredge was pumping, and the presence of large amounts of roe in two specimens and minimal decomposition indicates that the fish were alive and in good condition prior to entrainment. In January 1998, three shortnose sturgeon were discovered in the hydraulic maintenance dredge spoil in the Florence to Trenton section of the upper Delaware River. These fish also appeared to have been alive and in good condition prior to entrainment.

According to the Philadelphia District Endangered Species Monitoring Program, which began in August 1992, the deepening of the Federal Navigation Channel from Philadelphia to the Sea Project has not resulted in any observed shortnose or Atlantic sturgeon mortalities during hopper dredging events according to the. Since 2010, one Atlantic sturgeon was observed (entrained alive in May 2013) during maintenance dredging.

Since dredging involves removing the bottom material down to a specified depth, the benthic environment could be severely impacted by dredging operations. As sturgeon are benthic species, the alteration of the benthic habitat could have affected sturgeon prey distribution and/or foraging ability. Since 1998, the USACE has been avoiding dredging in the overwintering area during the time of year when sturgeon are present. Habitats affected by dredging projects in the Delaware River and Chesapeake Bay include foraging, overwintering and nursery habitats.

5.3 Blasting and Bridge Construction/Demolition

Bridge construction and demolition, dredging, and other projects may include plans for blasting with powerful explosive, which may interfere with normal shortnose and Atlantic sturgeon migratory movements and disturb areas of sturgeon concentrations. Fish are particularly susceptible to the effects of underwater explosions and are killed over a greater range than other organisms (Lewis 1996). Unless appropriate precautions are made to mitigate the potentially harmful effects of shock wave transmission to fish with swimbladders like sturgeon, internal damage and/or death may result (NMFS 1998c). A study testing the effects of underwater blasting on juvenile shortnose sturgeon and striped bass was conducted in Wilmington Harbor, NC in December of 1998 and January of 1999 (Moser 1999). There were seven test runs that included 23 to 33 blasts (three rows with 10 to 11 blast holes per row and each hole 10 ft apart) with about 24 to 28 kg explosives per hole. For each blast, 50 hatchery reared shortnose sturgeon and striped bass were placed in cages three feet from the bottom at distances of 35, 70, 140, 280 and 560 ft upstream and downstream of the blast area. A control group of 200 fish was held 0.5 mi from the blast site (Moser 1999). Test blasting was conducted with (3) and without (4) an air curtain placed 50 ft from the blast area. External assessments of impacts to the caged fish were conducted immediately after the blasts and 24 hours after the blasts. After the 24 hour period, a subsample of the caged fish, primarily from those cages nearest the blast at 35 ft and some from 70 ft, were sacrificed for necropsy.

Shortnose sturgeon selected for necropsy all appeared to be in good condition externally and behaviorally. Results of the tests, including necropsies, indicated the fish that had survived the blast, lived through the 24 hour observation period, and appeared outwardly fine. However, they may have had substantial internal injuries. Moser concluded that many of the injuries would have resulted in eventual mortality (Moser 1999). The necropsy results also indicated in the fish held in cages at 70 ft were less seriously injured by test blasting than those held at 35 ft from the blast. Finally, shortnose sturgeon juveniles suffered fewer, less severe internal injuries than juvenile striped bass tested, and there appeared to be no reduction of injury in fish experiencing blasts while the air curtain was in place (Moser 1999).

From 1993 through 1994, NMFS consulted with the Federal Highway Administration to assess the potential impacts of demolishing bridge piers to shortnose sturgeon. NMFS advised the Federal Highway Administration to employ several conservation measures designed to minimize the transmission of harmful shock waves. These measures included restricting the work to seasonal "work windows," installing double-walled cofferdams around each pier to be blasted, and dewatering the outer cofferdams. The use of an air gap (e.g., double-wall cofferdam, bubble screen) to attenuate shock waves is likely to reduce adverse effects to shortnose sturgeon and other swimbladder fish (Sonolysts 1994).

On June 11, 2010, NMFS issued a biological opinion on the Scudder Falls I-95 Bridge Improvement Project in Lambertville on the Delaware River. NMFS concluded that the proposed action of the bridge improvement project is likely to result in adverse effects to adult shortnose sturgeon by precluding them from accessing certain areas on the spawning grounds and causing them to alter their normal behaviors on the spawning grounds to avoid temporary and permanent structures. Additionally, NMFS concluded that the project is likely to result in adverse effects to larvae by resulting in the entrapment of larvae within cofferdams and the subsequent mortality of larvae from being pumped out of the cofferdams. Potential spawning habitat in the Delaware River has been identified as a 17 km stretch of the river extending from approximately Lambertville to the Trenton Rapids (Brundage 1986; ERC 2008; O'Herron II et al. 1993). The existing 1-95 bridge is located approximately 15 km downstream of Lambertville. Adult shortnose sturgeon are known to occur in that region of the Delaware River during spawning season and larval shortnose sturgeon are also expected to occur there for several weeks following the spawning period.

5.4 Water Quality and Contaminants

The quality of water in river/estuary systems is affected by human activities conducted in the riparian zone and those conducted more remotely in the upland portion of the watershed. Industrial activities can result in discharge of pollutants, changes in water temperature and levels of D.O., and the addition of nutrients. In addition, forestry and agricultural practices can result in erosion, run-off of fertilizers, herbicides, insecticides or other chemicals, nutrient enrichment and alteration of water flow. Coastal and riparian areas are also heavily impacted by real estate development and urbanization resulting in storm water discharges, non-point source pollution, and erosion. The Clean Water Act regulates pollution discharges into waters of the United States from point sources, however, it does not regulate non-point source pollution.

The water quality over the range of shortnose and Atlantic sturgeon varies by watershed but is notably poorer in the north than in the south. The U.S. Environmental Protection Agency (EPA) published its second edition of the National Coastal Condition Report (NCCR II) in 2005, a “report card” summarizing the status of coastal environments along the coast of the United States (USEPA 2005). The report analyzes water quality, sediment, coastal habitat, benthos, and fish contaminant indices to determine status. The northeast region of the U.S. (Virginia to Maine) received grades of F. Areas of concern having poor index scores for the Delaware River were water quality and tissue contaminants. Nutrient pollution is the largest problem currently affecting the Chesapeake Bay. Chemicals such as chlordane, dichlorodiphenyl dichloroethylene (DDE), DDT, dieldrin, PCBs, cadmium, mercury, and selenium settle to the river bottom and are later consumed by benthic feeders, such as macroinvertebrates, and then work their way higher into the food web (e.g., to sturgeon). Some of these compounds may affect physiological processes and impede a fish's ability to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing dissolved oxygen, altering pH, and altering other physical properties of the water body.

Life history of sturgeon (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose them to long-term, repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979; NMFS 1998c). However, there has been little work on the effects of contaminants on shortnose and Atlantic sturgeon to date. Shortnose sturgeon collected from the Delaware and Kennebec Rivers had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, DDE, aluminum, cadmium, and copper above reported adverse effect concentration levels (ERC 2002).

Heavy metals and organochlorine compounds accumulate in sturgeon tissue, but their long-term effects are not known (Ruelle and Henry 1992; Ruelle and Keenlyne 1993). High levels of contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Billsson et al. 1998; Cameron et al. 1992; Giesy et al. 1986; Hammerschmidt et al. 2002; Longwell et al. 1992; Mac and Edsall 1991; Matta et al. 1998), reduced survival of larval fish (Giesy et al. 1986; Willford et al. 1981), delayed maturity (Jorgensen and Weatherley 2003) and posterior malformations (Billsson et al. 1998). Pesticide exposure in fish may affect anti-predator and homing behavior, reproductive function, physiological maturity, swimming speed, and distance (Beauvais et al. 2000; Moore and Waring 2001; Scholz et al. 2000; Waring and Moore 2004).

Sensitivity to environmental contaminants also varies by life stage. Early life stages of fish appear to be more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). Dwyer et al. (2005) compared the relative sensitivities of common surrogate species used in contaminant studies to 17 listed species including shortnose and Atlantic sturgeons. The study examined 96-hour acute water exposures using early life stages where mortality is an endpoint. Chemicals tested were carbaryl, copper, 4-nonphenol, pentachlorophenal (PCP) and permethrin. Of the listed species, Atlantic and shortnose sturgeon were ranked the two most sensitive species tested (Dwyer et al. 2005). Additionally, a study examining the effects of coal tar, a byproduct of the process of destructive distillation of bituminous coal, indicated that components of coal tar are toxic to shortnose sturgeon embryos and larvae in whole sediment flow-through and coal tar elutriate static renewal (Kocan et al. 1993).

5.5 Vessel Operations and Vessel Strike

Potential adverse effects from federal vessel operations in the action area of this consultation include operations of the U.S. Navy and the U.S. Coast Guard, which maintain the largest federal vessel fleets, the EPA, NOAA, and the USACE. NMFS has conducted formal consultations with the U.S. Coast Guard, the U.S. Navy, EPA and NOAA on their vessel operations. In addition to operation of USACE vessels, NMFS has consulted with the USACE to provide recommended permit restrictions for operations of contract or private vessels around whales. Through the section 7 process, where applicable, NMFS has and will continue to establish conservation measures for all these agency vessel operations to avoid adverse effects to listed species. Refer to the biological opinions for the U.S. Coast Guard (NMFS 1995; 1996; 1998a) and the U. S. Navy (NMFS 1997; 2013) for detail on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures. No interactions with sturgeon have been reported with any of the vessels considered in these opinions. Private and commercial vessels, including fishing vessels, operating in the action area of this consultation also have the potential to interact with sea turtles.

Approximately 3,000 cargo vessels transit the Delaware River annually as well as numerous smaller commercial and recreational vessels. The effects of fishing vessels, recreational vessels, or other types of commercial vessels on listed species may involve disturbance or injury/mortality due to collisions or entanglement in anchor lines. There is limited information on the effects of vessel operations on shortnose sturgeon. It is generally assumed that as shortnose sturgeon are benthic species, that their movements are limited to the bottom of the water column and that vessels operating with sufficient navigational clearance would not pose a risk of ship strike. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to the larger Atlantic sturgeon, for which ship strikes have been documented more frequently. However, anecdotal evidence suggests that shortnose sturgeon at least occasionally interact with vessels, as evidence by wounds that appear to be caused by propellers.

There has been only one confirmed incidence of a ship strike on a shortnose sturgeon and 2 suspected ship strike mortalities. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20 ft) boat transiting a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. The other two suspected ship strike mortalities occurred in the Delaware River. On June 8, 2008, a shortnose was collected near Philadelphia. The fish was necropsied and found to have suffered from blunt force trauma; though there was no ability to confirm whether the source of the trauma resulted from a vessel interaction. Lastly, on November 28, 2007, a shortnose sturgeon was collected on the trash racks of the Salem Nuclear Generating Facility. The fish was not necropsied, however, a pattern of lacerations on the carcass suggested a possible vessel interaction. Aside from these incidents, no information on the characteristics of vessels that are most likely to interact with shortnose sturgeon is available and there is no information on the rate of interactions, however it is assumed to be low.

As noted in the ASSRT (2007) Status Review and the final listing rules, vessel strikes have been identified as a threat to Atlantic sturgeon. While the exact number of Atlantic sturgeon killed as a result of being struck by boat hulls or propellers is unknown, it is an area of concern. Brown and Murphy (2010) examined 28 dead Atlantic sturgeon observed in the Delaware River from 2005 through 2008. Fifty-percent of the mortalities resulted from apparent vessel strikes and 71 percent of these (10 of 14) had injuries consistent with being struck by a large vessel (Brown and Murphy 2010). Eight of the fourteen vessel-struck sturgeon were adult-sized fish(Brown and Murphy 2010). Given the time of year in which the fish were observed (predominantly May through July; Brown and Murphy 2010), it is likely that many of the adults were migrating through the river to or from the spawning grounds. In the James River, Virginia, Atlantic sturgeon mortality from ship strikes has also been documented. Thirty-one dead Atlantic sturgeon were recovered between 2007-2010, 26 with gashes likely made by vessels propellers (Balazik et al. 2012). The factors relevant to determining the risk to Atlantic sturgeon from vessel strikes are currently unknown, but they may be related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of Atlantic sturgeon in the area (e.g., foraging, migrating, etc.). The extent of mortalities documented by Brown and Murphy (2010) is unknown to accurately characterize the magnitude of vessel strikes in the Delaware River, but as it is unlikely that all Atlantic sturgeon mortalities during the study dates were observed by the authors. It is likely that there are other undocumented mortalities resulting from vessel strikes as well as from other sources.

5.6 Land Use Practices

In all, the Delaware River basin contains 13,539 square miles, draining parts of Pennsylvania, New Jersey, New York, and Delaware (DRBC 2009). Included in the total area number is the 782 square-mile Delaware Bay, which sits roughly half in New Jersey and half in Delaware. The major rivers draining into the Delaware are the Lehigh and Schuylkill Rivers. The Chesapeake Bay basin comprises approximately 64,000 square miles, and extends into New York, Pennsylvania, Maryland, West Virginia, and Virginia. Six major rivers drain into the basin: the Susquehanna, Potomac, Rappahannock, Patuxent, York and James (Langland et al. 1995). Because both basins make up such a large area over heavily populated regions, the region is subject to a variety of land use practices that influence the water quality of the watersheds.

Urbanization, increases in population and associated human activities are adversely affecting estuaries in the region. These pressures are expected to increase into the future as the population grows. The population in the Mid-Atlantic region (including both the Delaware River and Chesapeake Bay basins) is expected to reach 25 million by 2020 (EPA 1998). The Delaware River and Chesapeake Bay watersheds are primarily divided between developed, agriculture, forest, wetlands and water, and “other” including mining uses (DRBC 2008). In the Delaware Bay basin, the most heavily urbanized areas are at the lower extent of the watershed region, where large industrialized cities such as Philadelphia, Pennsylvania, Wilmington, Delaware, Camden, New Jersey, and Trenton, New Jersey are found.

Rising populations and urbanization in and around the Delaware River and Chesapeake Bay may lead to decreased water quality (increased contaminants), increased need for dredging and bridge building (and rebuilding), increased vessel traffic, and an increased need for power plants and operations; all of which can have negative impacts on sturgeon to some degree.

5.7 Power Plant Operations

Shortnose sturgeon are susceptible to impingement on cooling water intake screens at power plants. Electric power and nuclear power generating plants can affect sturgeon by impinging larger fish on cooling water intake screens and entraining larval fish. The operation of power plants can have unforeseen and extremely detrimental impacts to water quality which can affect shortnose and Atlantic sturgeon, and has been identified as a concern to both species throughout their range (ASSRT 2007; SSSRT 2010).

There are several commercial nuclear power plants currently operating in the Chesapeake Bay region, including Calvert Cliffs in Maryland, and North Anna and Surry in Virginia.[3] In its environmental impact statement for the operation of the Calvert Cliffs Nuclear Power Plant, the NRC reported that twenty years of impingement sampling had not collected any shortnose or Atlantic sturgeon. Atlantic or shortnose sturgeon were not found in the entrainment studies conducted at the plant from 2006-2007 (NRC 2011).

Public Service Enterprise Group Nuclear operates two nuclear power plants pursuant to licenses issued by the U.S. Nuclear Regulatory Commission (NRC) on the Delaware River. These facilities are the Salem and Hope Creek Generating Stations (Salem and HCGS), which are located on adjacent sites within a 740-acre parcel of property at the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. Consultation pursuant to Section 7 of the ESA between NRC and NMFS on the effects of the operation of these facilities has been ongoing since 1979. Salem Unit 1 will cease operations in 2036 and Salem Unit 2 will cease operations in 2040. Hope Creek is authorized to operate until 2046. An opinion was issued by NMFS in April 1980 in which NMFS concluded that the ongoing operation of the facilities was not likely to jeopardize the continued existence of shortnose sturgeon. Consultation was reinitiated in 1988 due to the documentation of impingement of sea turtles at the Salem facility. An opinion was issued on January 2, 1991 in which NMFS concluded that the ongoing operation was not likely to jeopardize shortnose sturgeon, Kemp's Ridley, green, or loggerhead sea turtles. Consultation was reinitiated in 1992 and a new Opinion was issued on August 4, 1992 and again on May 14, 1993. In 1998 the NRC requested that NMFS modify the Reasonable and Prudent Measures and Terms and Conditions of the incidental take statement, and, specifically, remove a sea turtle study requirement. NMFS responded to this request in a letter dated January 21, 1999 and also with a revised ITS which served to amend the May 14, 1993 opinion. The 1999 ITS exempts the annual take (capture at intake with injury or mortality) of five shortnose sturgeon, thirty loggerhead sea turtles, five green sea turtles, and five Kemp's Ridleys. Since monitoring of

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[3] http://www.nrc.gov/reactors/operating/map-power-reactors.html

the intakes was initiated in 1978 and through 2013, 25 shortnose sturgeon have been recovered from the Salem intakes, which are located in Delaware Bay. Reporting of Atlantic sturgeon began in 2011, and since then, a total of 21 Atlantic sturgeon have been observed at the Salem intakes through the end of 2013. No shortnose or Atlantic sturgeon have been observed at the HCGS intakes. See the most recent biological opinion (NMFS 2014) issued on July 17, 2014 for more information regarding the power plant operations.

5.8 Scientific Research

Research activities could also pose a threat to shortnose and Atlantic sturgeon. Excluding the proposed permits (No. 19331 and 19642) detailed in this opinion, fish held in captivity, and the import/export of fish parts, while including the three permits that the proposed permit would effectively renew or replace (No.14604, 16438 and 16547-01), there are approximately 19 active research permits authorizing the sampling (take) of shortnose and New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon on the east coast of the United States. Of these permits, six scientific research permits are issued pursuant to section 10(a)(1)(A) of the ESA, authorizing research on sturgeon in the Delaware River and Estuary, and one in the Chesapeake Bay.

5.9 Fishing Interactions and Bycatch

Directed harvest of shortnose and Atlantic sturgeon is prohibited. In 1998, the Atlantic States Marine Fisheries Commission (ASMFC) imposed a coast-wide fishing moratorium on Atlantic sturgeon until 20 year classes of adult females could be established (ASMFC 1998). NMFS followed this action by closing the Exclusive Economic Zone (EEZ) to Atlantic sturgeon take in 1999. Shortnose sturgeon has likely benefitted from this closure as any bycatch in the fishery targeting Atlantic sturgeon has been eliminated.

Although directed harvest of shortnose and Atlantic sturgeon are prohibited, bycatch of this species has been documented in other fisheries throughout its range. Adults are believed to be especially vulnerable to fishing gears for other anadromous species (such as shad, striped bass and herring) during times of extensive migration, particularly the spawning migration upstream, followed by movement back downstream (Litwiler 2001). Additionally, bycatch of shortnose sturgeon in the southern trawl fishery for shrimp *Penaeus* spp. was estimated at 8 percent in one study (Collins et al. 1996).

Although shortnose sturgeon are primarily captured in gill nets, they have also been documented in the following gears: pound nets, fyke/hoop nets, catfish traps, shrimp trawls, and hook and line fisheries (recreational). The NMFS (1998b) 1998 Recovery Plan for shortnose sturgeon lists commercial and recreational shad fisheries as a source of shortnose bycatch. Shad and river herring (blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengus*)) are managed under an ASMFC Interstate Fishery Management Plan. Recreational shad fishing is currently allowed within the Delaware River with hook and line only; commercial fishing for shad occurs with gill nets, but only in Delaware Bay.

Bycatch in gill net fisheries can be quite substantial and is believed to be a significant threat to shortnose and Atlantic sturgeon throughout the range of both species, in marine, riverine and estuarine habitats (ASSRT 2007; SSSRT 2010). The catch rates in drift gill nets are believed to be lower than for fixed nets; longer soak times of the fixed nets appear to be correlated with higher rates of mortalities. In an American shad gill net fishery in South Carolina, of 51 fish caught, 16 percent were bycatch mortality and another 20 percent of the fish were visibly injured (Collins et al. 1996). In the past, it was estimated that over 100 shortnose sturgeon were captured annually in shad fisheries in the Delaware River, with an unknown mortality rate (O'Herron II and Able 1985). Atlantic sturgeon have also been documented as bycatch in the Atlantic croaker fishery (James 2014). A test modification to gillnets used in the southern flounder (*Paralichthys lethostigma*) fishery demonstrated the potential to reduce bycatch and Atlantic sturgeon encounters by 49.4 percent and 60.9 percent (Levesque et al. 2016).

Fishing for weakfish occurs in both the Chesapeake and Delaware Bays, with dominant commercial gears including gill nets, pound nets, haul seines, and trawls, with the majority of landings occurring in the fall and winter months (ASMFC 2002). An earlier review of bycatch rates and landings for the weakfish fishery reported that the weakfish-striped bass fishery had an Atlantic sturgeon bycatch rate of 16 percent from 1989 to 2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of 0.02 percent, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0 percent (ASSRT 2007).

Striped bass are managed by ASMFC through Amendment 6 to the Interstate FMP, which requires minimum sizes for the commercial and recreational fisheries, possession limits for the recreational fishery, and state quotas for the commercial fishery (ASMFC 2003). Data from the Atlantic Coast Sturgeon Tagging Database (2000 to 2004) shows that the striped bass fishery accounted for 43 percent of Atlantic sturgeon recaptures; however, no information on the total number of Atlantic sturgeon caught by fishermen targeting striped bass or the mortality rate is available.

Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. No recent estimates of captures or mortality of shortnose or Atlantic sturgeon are available. In 2012, only one commercial fishing license was granted for shad in New Jersey. Shortnose and Atlantic sturgeon continue be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to these species are likely less than they were in the past.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy sturgeon fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO 2011; Wirgin and King 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian-directed Atlantic sturgeon fisheries and of Canadian fish incidentally captured in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year. Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

5.10 Climate Change

Climate change is relevant to the *Status of the Species*, *Environmental Baseline* and *Cumulative Effects* sections of this opinion; rather than include partial discussion in several sections of this opinion, we are synthesizing this information into one discussion.

5.10.1 Background information on global climate change

The global mean temperature has risen 0.76ºC over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a) and precipitation has increased nationally by 5 percent to 10 percent, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b); these trends are most apparent over the past few decades.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20 percent). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3° to 5°C on average in the next 100 years, which is more than the projected global increase (NAST 2000). A warming of about 0.2°C per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007c). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene et al. 2008).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene et al. 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of 91 freshwater to the North Atlantic (Greene et al. 2008; IPCC 2007a). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2007a). The NAO impacts climate variability throughout the northern hemisphere (IPCC 2007a). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000 m deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006; IPCC 2007a). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene et al. 2008; IPCC 2007a). There is evidence that the NADW has already freshened significantly (IPCC 2007a). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene et al. 2008).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on coastal and marine resources on smaller geographic scales, such as the Delaware River, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that the rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007c).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch et al. 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat currently degrade water quality (Murdoch et al. 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some 92 systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer et al. 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change.

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of D.O. and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm.

5.10.2 Climate change in relation to shortnose and atlantic sturgeon

Climate change has the potential to affect Atlantic and shortnose sturgeon. Elevated air temperatures could lead to precipitation falling as rain instead of snow. Additionally, snow would likely melt sooner and more rapidly, potentially leading to greater flooding during melting and lower water levels at other times, as well as warmer river temperatures (ISAB 2007). It is possible that the effects of climate change could have localized effects and regional differences with areas of the country being affected by these factors to varying degrees based on localized features such as elevation and human population density (SSSRT 2010). Increased extremes in river flow (i.e., periods of flooding and low flow) can alternatively disrupt and fill in spawning habitat that sturgeon rely upon (ISAB 2007). Although sturgeon can spawn over varied benthic habitat, they prefer localized depressions in riverbeds (Erickson et al. 2001; Moyle et al. 1992; Moyle et al. 1995; Rien et al. 2001).

Shortnose and Atlantic sturgeon are uniquely evolved to the environments that they live in. Because of this specificity, broad scale changes in environment can be difficult to adapt to, including changes in water temperature (Cech Jr. et al. 2000). Sturgeon are also directly sensitive to elevated water temperatures. Temperature triggers spawning behavior. Warmer water temperatures can initial spawning earlier in a season for salmon and the same can be true for sturgeon (ISAB 2007). If water temperatures become anomalously warm, juvenile sturgeon may experience elevated mortality due to lack of cooler water refuges. If temperature rise beyond thermal limits for extended periods, habitat can be lost; this could be the case if southern habitats warm, resulting in range loss (Lassalle et al. 2010). Climate change was identified as a particular threat for Atlantic sturgeon in the South Atlantic and Carolina DPSs.

Apart from direct changes to sturgeon survival, altered water temperatures may disrupt habitat, including the availability of prey (ISAB 2007). Warmer temperatures may also have the effect of increasing water use in agriculture, both for existing fields and the establishment of new ones in once unprofitable areas (ISAB 2007). This means that streams, rivers, and lakes will experience additional withdrawal of water for irrigation and increasing contaminant loads from returning effluent. Overall, it is likely that global warming will increase pressures on sturgeon survival and recovery throughout its range.

5.10.3 Potential effects of climate change in the action area

Available information on climate change related effects for the Delaware River largely focuses on effects that rising water levels may have on the human environment (Barnett et al. 2008) and the availability of water for human use (e.g., Ayers et al. 1994). Documents prepared by USACE for the Philadelphia to the Sea deepening project have considered climate change (USACE 2009; USACE 2011), with a focus on sea level rise and a change in the location of the salt line.

Kreeger et al. (2010) considers effects of climate change on the Delaware Estuary. Using an average of 14 models, an air temperature increase of 1.9 to 3.7°C over this century is anticipated, with the amount dependent on emissions scenarios. No predictions related to increases in river water temperature are provided. There is also a 7 to 9 percent increase in precipitation predicted as well as an increase in the frequency of short term drought, a decline in the number of frost days, and an increase in growing season length predicted by 2100.

The report notes that the Mid-Atlantic States are anticipated to experience sea level rise greater than the global average (GCRP 2009). While the global sea level rise is largely attributed to melting ice sheets and expanding water as it warms, there is regional variation because of gravitational forces, wind, and water circulation patterns. In the Mid-Atlantic region, changing water circulation patterns are expected to increase sea level by approximately 10 cm over this century (Yin et al. 2009 in Kreeger et al. 2010). Subsidence and sediment accretion also influence sea level rise in the Mid-Atlantic, including in the Delaware estuary. As described by Kreeger et al. (2010), postglacial settling of the land masses has occurred in the Delaware system since the last Ice Age. This settling causes a steady loss of elevation, which is called subsidence. Through the next century, subsidence is estimated to hold at an average 1 to 2 mm of land elevation loss per year (Engelhart et al. 2009 in Kreeger et al. 2010). Rates of subsidence and accretion vary in different areas around the Delaware Estuary, but the greatest loss of shoreline habitat is expected to occur where subsidence is naturally high in areas that cannot accrete more sediments to compensate for elevation loss plus absolute sea level rise. The net increase in sea level compared to the change in land elevation is referred to as the rate of relative sea level rise (RSRL). Kreeger et al. (2010) stated that the best estimate for RSLR by the end of the century is 0.8 to 1.7 m in the Delaware Estuary.

Sea level rise combined with more frequent droughts and increased human demand for water are predicted to result in a northward movement of the salt wedge in the Delaware River (Collier 2011). Currently, the normal average location of the salt wedge is at approximately river kilometer (rkm) 114. Collier predicts that without mitigation (e.g., increased release of flows into downstream areas of the river), at high tide in the peak of the summer during extreme drought conditions, the salt line could be as far upstream as rkm 183 in 2050 and rkm 188 in 2100. The farthest north the salt line has historically been documented was approximately rkm 166 during a period of severe drought in 1965; thus, she predicts that over time, during certain extreme conditions, the salt line could shift up to 18 km further upstream by 2050 and 22 km further upstream by 2100.

A hydrologic model for the Delaware River, incorporating predicted changes in temperature and precipitation was compiled by Hassell and Miller (1999). The model results indicate that when only the temperature increase is input to the hydrologic model, the mean annual streamflow decreased, the winter flows increased due to increased snowmelt, and the mean position of the salt front moved upstream. When only the precipitation increase was input to the hydrologic model, the mean annual streamflow increased, and the mean position of the salt front moved further downstream. However, when both the temperature and precipitation increase were input to the hydrologic model the mean annual streamflow changed very little, with a small increase during the first four months of the year.

Sea surface temperatures have fluctuated around a mean for much of the past century, as measured by continuous 100+ year records at Woods Hole (Mass.), and Boothbay Harbor (Maine) and shorter records from Boston Harbor and other bays. Periods of higher than average temperatures (in the 1950s) and cooler periods (1960s) have been associated with changes in the North Atlantic Oscillation (NAO), which affects current patterns. Over the past 30 years 98 however, records indicate that ocean temperatures in the Northeast have been increasing; for example, Boothbay Harbor's temperature has increased by about 1°C since 1970. Water temperature in the Delaware River, including the action area, varies seasonally. A 2007 examination of long-term trends in Delaware River water temperature shows no indication of any long-term trends in these seasonal changes (BBL 2007). Monthly mean temperature in 2001 compares almost identically to long-term monthly mean temperatures for the period from 1964 to 2000, with lowest temperatures recorded in April (10 to 11°C) and peak temperatures observed in August (approximately 26 to 27°C). While water temperature rises have been observed in other mid-Atlantic rivers (e.g., a 2°C increase in the Hudson River from the 1960s to 2000s, Pisces Conservation Ltd. 2008), a similar trend does not currently appear in the Delaware River.

While we are not able to find predictive models for water temperature in Delaware Bay or the Delaware River, given the geographic proximity of these waters to the Northeast, we assume that predictions would be similar. For marine waters, the model projections are for an increase of somewhere between 3 to 4°C by 2100 and a pH drop of 0.3 to 0.4 units by 2100 (Frumhoff et al. 2007). Assuming that these predictions also apply to the action area, one could anticipate similar conditions in the action area over that same time period.

Over the long term, global climate change may affect shortnose and Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. The most likely effect to shortnose and Atlantic sturgeon would be if sea level rise was great enough to consistently shift the salt wedge far enough north which would restrict the range of juvenile sturgeon and may affect the development of these life stages. Upstream shifts in spawning or rearing habitat in the Delaware River are not limited by any impassable falls or manmade barriers. Habitat that is suitable for spawning is known to be present upstream of the areas that are thought to be used by shortnose and Atlantic sturgeon suggesting that there may be some capacity for spawning to shift further upstream to remain ahead of the saltwedge. Based on predicted upriver shifts in the saltwedge, areas where Atlantic sturgeon currently spawn could, over time, become too saline to support spawning and rearing. Modeling conducted by the ACOE indicates that this is unlikely to occur before 2040 but modeling conducted by Collier (2011) suggests that by 2100 areas where spawning is thought to occur (rkm 120 to 150 and 170 to 190), may be too salty and spawning would need to shift further north. Given the availability of spawning habitat in the river, it is unlikely that the saltwedge would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. The available habitat for juvenile sturgeon could decrease over time; however, even if the saltwedge shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon because there would still be sufficient freshwater habitat available.

However, there is substantial uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species, which may allow them to deal with change better than predicted.

In 2008, the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) reviewed the current understanding of climate change impacts on the tidal Chesapeake Bay and identified critical knowledge gaps and research priorities (Pyke et al. 2008). The report notes that the Bay is sensitive to climate-related forcings of atmospheric CO2 concentration, sea level, temperature, precipitation, and storm frequency and intensity and that scientists have detected significant warming and sea-level-rise trends during the 20th century in the Chesapeake Bay. Climate change scenarios for CO2 emissions examined by STAC suggest that the region is likely to experience significant changes in climatic conditions throughout the 21st century including increases in CO2 concentrations, sea level rise of 0.7 to 1.6 m, and water temperature increasing by up to 2° to 6°C. The STAC also indicated that other changes are likely, but less certain, including increases in precipitation quantity (particularly in winter and spring), precipitation intensity, intensity of tropical and extratropical cyclones (though their frequency may decrease), and sea-level variability. Changes in annual streamflow are highly uncertain, though winter and spring flows will likely increase. The report notes that changes in human activities over the next century have the potential to either exacerbate or ameliorate the predicted climatically induced changes. Given the uncertainty in precipitation and streamflow forecasts, the direction of some changes remains unknown; however, the report states that certain consequences appear likely including increasing sea level in the Bay: increasing variability in salinity due to increases in precipitation intensity, drought, and storminess; more frequent blooms of harmful algae due to warming and higher CO2 concentrations; potential decreases in the prevalence of eelgrass; possible increases in hypoxia due to warming and greater winter-spring streamflow; and, altered interactions among trophic levels, potentially favoring warm-water fish and shellfish species in the Bay.

In 2010, EPA conducted a preliminary assessment of climate change impacts on the Chesapeake Bay using a version of the Phase 5 Bay Watershed Model and tools developed for EPA's BASINS 4 system including the Climate Assessment Tool. Flows and associated nutrient and sediment loads were assessed in all river basins of the Chesapeake Bay with three key climate change scenarios reflecting the range of potential changes in temperature and precipitation in the year 2030. The three key scenarios came from a larger set of 42 climate change scenarios that were evaluated from 7 Global Climate Models, 2 scenarios from the IPCC Special Report on Emissions Scenarios storylines, and 3 assumptions about precipitation intensity in the largest events. The 42 climate change scenarios were run on the Phase 5 Watershed Model of the Monocacy River watershed, a sub-basin of the Potomac River basin in the Piedmont region, using a 2030 estimated land use based on a sophisticated land use model containing socioeconomic estimates of development throughout the watershed.

The results provide an indication of likely precipitation and flow patterns under future potential climate conditions (Linker et al. 2008). Projected temperature increases tend to increase evapotranspiration in the Bay watershed, effectively offsetting increases in precipitation. The preliminary analysis indicated overall decreases in annual stream flow as well as decreases in nitrogen and phosphorus loads. The higher intensity precipitation events yielded estimated increases in annual sediment loads.

5.11 Conservation

There are several organizations in place to promote the conservation of the Delaware and Chesapeake Bay basins, aimed broadly at improving water quality and habitat. Such policies, if properly implemented, can improve conditions for aquatic life in the basins, including shortnose and Atlantic sturgeon.

The Delaware River Basin Commission was established in 1961 as a regional body with the force of law to oversee management of the Delaware River system. Similarly, the Chesapeake Bay Commission was created in 1980 to coordinate policy for management of the Bay. Commission programs include water quality protection, water supply allocation, regulatory review (permitting), watershed planning, drought management, flood loss reduction, and recreation. Furthermore, the Delaware River Basin Commission has embarked on a water conservation program which adopts policies to reduce the demand for water.

The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. Portions of the upper, middle, and lower Delaware River are part of the National Wild and Scenic Rivers System. This designation is significant, because it keeps the Delaware free of large dams and hydroelectric projects. There are no wild and scenic rivers designated in Maryland or Virginia.

Section 303(d) of the Federal Clean Water Act requires States to develop a list (303(d) List) of waterbodies for which existing pollution control activities are not sufficient to attain applicable water quality standards and to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. A TMDL sets a limit on the amount of a pollutant that can be discharged into a waterbody such that water quality standards are met. The states surrounding the Delaware River and Chesapeake Bay basins are responsible for implementing TMDLs.

All of the states along the Delaware River and Chesapeake Bay have State Departments of Conservation managing programs which impact the Delaware River and Chesapeake Bay Basin such as air, waste, soil, water, fish, and wildlife. The Delaware Department of Natural Resources, Division of Fish and Wildlife conducts biological surveys and studies of living resources throughout the state, manages approximately 60,000 acres including ponds, wildlife and water access areas and facilities for public use and enjoyment, and improves the public's understanding and interest in the state's fish and wildlife resources through information and outreach programs. The Pennsylvania Department of Conservation and Natural Resources (PDCNR) also manages many conservation programs. The Pennsylvania Rivers Conservation Program was developed by PDCNR to conserve and enhance river resources through preparation and accomplishment of locally initiated plans. The program provides technical and financial assistance to municipalities and river support groups to carry out planning, implementation, acquisition and development activities. The Pennsylvania Natural Heritage Program is a member of NatureServe, an international network of natural heritage programs that gather and provide information on the location and status of important ecological resources, including threatened and endangered species. The Natural Resources and Conservation Service of New Jersey has a conservation stewardship program, awards multiple conservation grants, leads a wetlands reserve program and a wildlife habitat incentives program. The New York Department of Environmental

Conservation has an Endangered Species Program, State Wildlife Grants Program, and a Natural Heritage Program.

5.12 Conclusion on the Impact of the Environmental Baseline

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed shortnose and New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon considered in this opinion. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, power plant operation, fishing bycatch, blasting and construction), whereas others result in more indirect (e.g., scientific research, water quality, dredging, climate change) impacts. Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult and, to our knowledge, no such analysis exists. This becomes even more difficult considering that some of the species in this opinion are wide ranging and subject to stressors in locations beyond the Action Area. We consider the best indicator of the aggregate impact of the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species, which shortnose sturgeon and New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS of Atlantic sturgeon are considered endangered and undergoing declines in population abundance and the Gulf of Maine DPS of Atlantic sturgeon is considered threatened. A thorough review of the status and trends of each species is presented in the *Status of the Species* section of this opinion.

6 EFFECTS OF THE ACTION ON ESA-LISTED SPECIES

Under Section 7(a)(2) of the ESA, Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed activities authorized by Permit No. 19331 and No. 19642 would expose ESA-listed Atlantic and shortnose sturgeon to gill, trammel, and trawl net capture; pound net, Fyke/Hoop net, beach seines capture; capture and mortality of early life stage individuals; handling; genetic tissue sampling; PIT, T-bar, and JSAT tagging; anesthesia; internal acoustic tagging; gastric lavaging; fin ray clipping; hydro-acoustic testing; recaptures; and incidental mortality

In this section, we describe the:

- potential physical, chemical, or biotic stressors associated with the proposed action;
- probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available;
- probable responses of those individuals (given probable exposures) based on the available evidence.

Any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success) would be assessed to consider the risk posed to the viability of the listed population. The purpose of this assessment is to determine if it is reasonable to expect the proposed studies to have an effect on the listed population that could appreciably reduce their likelihood of surviving and recovering in the wild.

6.1 Stressors

The assessment for this consultation identified the following possible stressors associated with the proposed permitted activities that could pose a risk to Atlantic and shortnose sturgeon: 1) gill, trammel, and trawl net capture; 2) Pound net, Fyke/Hoop net, beach seines capture; 3) Capture and mortality of early life stage; 4) handling for procedures and measurements; 5) genetic tissue sampling; 6) PIT tagging; 7) T-bar tagging; 8) JSAT tagging; 9) anesthesia; 10) internal acoustic tagging; 11) gastric lavaging; 12) fin ray clipping; 13) Hydro-acoustic testing; 14) recaptures; and 15) incidental mortality. Activities will occur in the Delaware River and Estuary, Chesapeake Bay and all of its rivers and tributaries, the Atlantic Ocean, and will occur annually from the date of the permit's issuance until its expiration (five years from the date of issuance).

6.2 Exposure

Exposure analyses identify the co-occurrence of ESA-listed species with the actions' effects in space and time, and identify the nature of that co-occurrence. The analysis identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulations(s) those individuals represent. As discussed previously, Atlantic and shortnose sturgeon of both genders and any age class could be exposed to stressors associated with the proposed action.

We have assessed the action at the proposed levels for all research activities. However, we believe that in any given year, not all proposed takes may occur since researchers ask for takes based on a desired sample size and account for potential (though not necessarily likely or expected) encounters with larger numbers of animals that could occur while conducting field research. The take levels requested and analyzed in this opinion are in Section 2.1 and 2.2.

6.3 Response

As discussed in the *Approach to the Assessment* section of this opinion, response analyses determine how listed species are likely to respond after being exposed to an action's stressors. Below we discuss the expected response of Atlantic and shortnose sturgeon to the stressors identified in Section 6.1. Additional details on the proposed methodology are in Section 2.1and 2.2.

6.3.1 Capture by gill, trammel, and trawl net capture

Sturgeon affected by the proposed action will be entangled in gillnets (i.e., mostly drifting monofilament nylon gillnets, though the researchers are also permitted to use anchored gillnets), trammel, and trawl nets. Entanglement in nets can result in injury and mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Collins et al. 2000a; Kahn and Mohead 2010; Moser and Ross 1995). To illustrate, shortnose sturgeon mortality resulting from six similar scientific research permits utilizing gillnetting is summarized in Table 15 below. Mortality rates due to the netting activities ranged from 0 to 1.22 percent. 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 percent. All of the mortalities associated with these permits were due to high water temperature and low dissolved oxygen (D.O.) concentrations. Moser and Ross (1995) reported gill net mortalities approached 25 percent when water temperatures exceeded 28ºC, even though soak times were often less than four hours. Under Permit Number 1247, between 4 and 7 percent 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.

Table 15. Number and percentage of shortnose sturgeon killed by gill and trammel nets associated with scientific research permits before 2005.

	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

For all species, research has revealed that survival is affected by temperature, dissolved oxygen, and salinity, and this vulnerability may be increased by the research-related stress of capture, holding, and handling (Kahn and Mohead 2010) since 2006, conservative mitigation measures implemented by NMFS and researchers (e.g., reduced soak times at warmer temperatures or lower dissolved oxygen concentrations, minimal holding or handling time) have reduced the effects of capture by gill netting on sturgeon significantly with no documented mortalities. These measures are consistent with research on shortnose and Atlantic sturgeon which has indicated that survival was affected by reduced D.O., increased temperature, and increased salinity (summarized in Kahn and Mohead 2010). While netting, researchers will take necessary precautions ensuring sturgeon are not harmed including: (1) continuously monitoring nets; (2) removing animals from nets as soon as capture is recognized; and (3) following the water temperature, minimum D.O. level, and net set duration guidelines outlined in Section 2. These actions are expected to substantially reduce the likelihood of killing sturgeon during research activities.

As demonstrated above, there is a chance that Atlantic or shortnose sturgeon could die in these nets. 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 the conservative set of netting conditions outlined in Kahn and Mohead (2010).

Although most fish will not experience reduced fitness, incidental mortality could rarely occur. This is discussed further in Section 6.3.13. With the exception of rare instances of incidental mortality, the capture methodology as proposed is not likely to reduce fitness of individual fish, and would not affect the viability of Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon populations. By extension, capture is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

6.3.2 Capture by pound net, fyke net, hoop net, and beach seines

Atlantic and shortnose sturgeon from both permits would be captured by net. Pound nets, fyke/hoop nets, beach seines and other trap nets would be authorized in the Delaware River, Chesapeake Bay and tributaries. Additionally, because of potential for turtle interaction with pound, fyke, and other trap nets under Permit No. 19642, these gear would only be used by researchers when sea turtles are not anticipated in the action area (for example, from December to April).

Since fish are trapped, not hooked or gilled, in pound, beach, 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 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. Upon consultation with the research and a review of the environmental conditions, NMFS Permits Division may authorize additional holding of an unstressed captured Atlantic sturgeon for up to 24 hours in a pound net. Beach seines are 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.

Because 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.

Although most fish will not experience reduced fitness, incidental mortality could rarely occur. This is discussed further in Section 6.3.13. With the exception of rare instances of incidental mortality, the capture methodology as proposed is not likely to reduce fitness of individual fish, and would not affect the viability of Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon populations. By extension, capture is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the netting protocols are used and closely followed.

6.3.3 Capture and mortality of early life stage

Permit 19331 and 19642 would use egg mats, D-mats or sleds to collect early life stages. Five hundred ELS from the New York Bight DPS, and 500 from the Chesapeake Bay DPS, would be taken each year. Because of their large size, female Atlantic sturgeon are highly 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 (Dadswell 2006; Smith et al. 1982; Van Eenennaam et al. 1996; Van Eenennaam and Doroshov 1998). Female gonad weight varies from 12 to 25 percent of the total body weight (Dadswell 2006; Huff 1975). 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 to 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 is not expected to adversely affect 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 and Chesapeake Bay DPSs, the proposed action would collect 0.10 percent, 0.006 percent, 0.01 percent, and 0.08 percent of the eggs produced in that year from each DPS, respectively. As such, the annual proposed take of early life stage 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 early life stage would likely result in more timely and conclusive data pertaining to sturgeon spawning.

We do not expect the collection of the proposed amounts of early life stage annually from the New York Bight and Chesapeake Bay 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 percent to 0.08 percent of that one female's total annual spawning production. Therefore, the early life stage collection methodology as proposed is unlikely to reduce the survival and recovery of the Atlantic sturgeon populations in the New York Bight DPS and Chesapeake Bay DPS and as listed under the ESA. This conclusion can be reached as long as proposed methods are closely followed.

6.3.4 Handling for procedures and measurements

All sturgeon would be handled for length and weight measurements and/or the other proposed methods under this proposed research authorization. Handling and restraining sturgeon may cause short term stress responses, but those responses are not likely to result in long-term adverse effects 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 dissolved oxygen is low (Kahn and Mohead 2010; Moser et al. 2000). Sturgeon may inflate their swim bladder when held out of water (Kahn and Mohead 2010; Moser et al. 2000) 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).

Although sturgeon are sensitive to handling stress, handling of fish will be kept to a minimum. Per the permit conditions, once captured the total handling time for onboard procedures for individual sturgeon will not exceed 20 minutes. For fish that are not anesthetized, handling times of individual fish would be much lower (i.e., under two minutes). Recovery times will vary, but are expected to last for approximately 30 seconds for fish that are not anesthetized and less than 30 minutes for fish that are anesthetized. Fish will not be held for more than two hours in a live care unless they have not yet recovered from anesthesia.

The proposed methods of handling fish are consistent with the best management practices recommended by Kahn and Mohead (2010) and endorsed by NMFS (Damon-Randall et al. 2010) and, as such, should minimize the potential handling stress and indirect effects resulting from handling in the proposed research. To minimize capture and handling stress, the proposed research plans to hold sturgeon in maintained net pens until they are processed, at which time they would be transferred to a processing station onboard the research vessel. The total handling time for onboard procedures for individual sturgeon will not exceed 20 minutes. 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, or the viability of Delaware River, York, Rappahannock, Potomac, and Susquehanna

Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast Atlantic or shortnose sturgeon populations. By extension, handling is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.5 Genetic tissue sampling

Immediately prior to each sturgeon's release, 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 scissors. This procedure does not harm sturgeon (Kahn and Mohead 2010) 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. Therefore, we do not anticipate any long-term adverse effects to individual sturgeon from this activity and, as proposed, this activity is not likely to reduce the fitness of individuals or the viability of Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon populations. By extension, genetic tissue sampling is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.6 Passive Integrated Transponder tagging

All sturgeon captured that are previously unmarked would be marked with PIT tags. No fish would be double-tagged with PIT tags since the entire dorsal surface of each fish would be scanned to detect previous PIT tags before continuing with tagging. PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996; Dare 2003; Eyler et al. 2004; Skalski et al. 1998), amphibians (Thompson 2004), (Cheatwood et al. 2003; Germano and Williams 2005), birds (Boisvert and Sherry 2000; Green et al. 2004), and mammals (Hilpert and Jones 2005; Wright et al. 1998). 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; Clugston 1996; Elbin and Burger 1994; Hockersmith et al. 2003; Jemison et al. 1995; Keck 1994; Skalski et al. 1998). 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. Additionally, 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 (Bégout Anras et al. 2003; Bergman et al. 1992; Brattey and Cadigan 2004; Isaksson and Bergman 1978; Lacroix et al. 2005; Morgan and Roberts 1976; Strand et al. 2002; Sutton and Benson 2003). Larger tags and external tags have more adverse consequences (e.g., impaired swimming) than smaller tags (Bégout Anras et al. 2003; Sutton and Benson 2003). These biologically inert tags have been shown not to cause some of the problems associated with other methods of tagging fish, that is, scarring and damaging tissue or otherwise adversely affecting growth or survival (Brännäs et al. 1994).

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 percent of the yearling Chinook salmon (*Oncorhynchus tshawytscha*) and 0.3 percent of the yearling steelhead (*O. mykiss*) studied by Muir et al. (2001) died from PIT tag insertions after 24 hours. In a 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 percent mortality after 48 hours, but no additional mortalities after 28 days. Henne et al. (2008) also show that there is no mortality to sturgeon under 330 mm after 28 days if 11.5mm PIT tags are used. Gries and Letcher (2002) found that 0.7 percent 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 percent 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.

The majority of juvenile sturgeon proposed to be implanted with PIT tags will be over 300 mm. Tagging individuals of this size is consistent with the recommendations of Kahn and Mohead (2010) and Damon-Randall et al. (2010). This recommendation is based on Henne et al. (2008) which found that 11 and 14 mm length tags inserted into shortnose sturgeon longer than 300 mm was safe (cited in Kahn and Mohead 2010). However, the proposed action also involves tagging sturgeon as small as 250 mm using 8.4 mm length tags. Using this smaller tag is expected to reduce the likelihood of mortality over what would be expected if they used 11 and 14 mm length tags. We are not aware of any research efforts that have studied mortality rates of juvenile sturgeon less than 300 mm implanted with 8.4 mm PIT tags. However, recapture data from previous research by the applicant suggests that these small fish can survive this procedure and continue to grow (Ian Park, DNREC, unpublished data). All other recommendations outlined in Kahn and Mohead (2010) for PIT tagging will be followed by the researchers as part of the proposed action.

Based on the information presented above, the proposed tagging of sturgeon with PIT tags is unlikely to have long-term adverse impacts on individual fish. Therefore, the PIT tag methodology as proposed is not likely to reduce the fitness of individual fish, or the viability of Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast Atlantic and shortnose sturgeon populations. By extension, PIT tagging is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon and shortnose sturgeon as listed under the ESA.

6.3.7 T-bar tagging

The use of both T-bar and PIT tags to mark sturgeon is a duplicative means to identify captured fish. However, we believe that the practice is not expected to significantly impact sturgeon health. Generally, there is little observable reaction to the injection of PIT tags. The injection of T-bar tags may result in more noticeable reactions. There is also a greater potential for injury from the insertion of T-bar 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.

Injection of T-bar tags into the dorsal musculature may result in raw sores that may enlarge over time with tag movement (Collins et al. 1994; Guy et al. 1996). Beyond the insertion site, it is unknown what affects the attachment of T-bar tags may have. We know of no long-term studies evaluating the effect of these tags on the growth or mortality of tagged sturgeon. Anecdotal evidence recounted in NOAA’s outdated protocol Moser et al. (2000) suggests that T-bar tags have little impact on the fish because a number of shortnose were recovered about ten 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 result in changes in growth rates (Manire and Gruber 1991; Scheirer and Coble 1991; Tranquilli and Childers 1982).

To lessen known negative impacts described above using the T-bar tag, sterile tagging techniques will be used. 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 T-bar tags are other than insignificant, NMFS would reevaluate their use in the permit. Therefore, the T-bar tag methodology as proposed is not likely to reduce fitness in individual fish, or the viability of Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon populations. By extension, T-bar tagging is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.8 JSAT tagging

The injectable JSAT tag is a 1.5 cm long acoustic tag with a 100 day life-span, which can be injected in any sturgeon life stage (>300 mm) without surgery or anesthesia, similar to a PIT tag, in order to obtain information on in-river movement, habitat use, and residence times.

Due to the procedural similarity of JSAT tags to PIT tags, the proposed tagging of sturgeon with JSAT tags is unlikely to have long-term adverse impacts on individual fish. Therefore, the JSAT tag methodology as proposed is not likely to reduce the fitness of individual fish, or the viability of York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast. By extension, JSAT tagging is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon as listed under the ESA.

6.3.9 Anesthesia

Sturgeon selected for internal surgeries will be anesthetized using either MS-222 or electronarcosis.

6.3.9.1 MS-222

Tricaine methane sulfonate (MS-222) is a recommended chemical anesthetic for sturgeon research when used at correct concentrations (Kahn and Mohead 2010). Each sturgeon requiring anesthetization would be placed in a water bath solution containing buffered MS-222 for anesthetization (Summerfelt and Smith 1990). Concentrations of MS-222 up to 150 mg/L would be used. 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 rapidly absorbed through the gills and prevents 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 bradycardia, 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 (2011) 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, 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).

The above studies show the risks of MS-222 to 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), and (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).

The applicants aim to avoid the possibility of irreversible effects by following concentration recommendations and recovery procedures used in successful sturgeon studies with similar methodologies (Collins et al. 2006; Collins et al. 2008; Haley 1998; Moser et al. 2000). The applicants have previously been authorized to perform anesthesia under their research permits for shortnose and Atlantic sturgeon. Additionally, the applicants will only anesthetize non-stressed animals, use restraint in containers to prevent animals from jumping or falling out, and will observe sturgeon for proper recovery from anesthesia prior to release. Based on our review of available information, the prior shortnose sturgeon and Atlantic sturgeon anesthetization experience the applicants have had, and mitigation measures included in the permit conditions that would minimize the effects of the anesthetic, we believe that MS-222 anesthesia is not likely to reduce the fitness of individual Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon or reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA. This conclusion can be reached as long as the appropriate concentrations of MS-222 are used and proposed duration of exposure is closely followed.

6.3.9.2 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). 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). Induction and recovery from electronarcosis both take less than one minute while induction and recovery takes place in three to five minutes and five to seven minutes respectively with MS-222. 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; Henyey et al. 2002; Summerfelt and Smith 1990). In a study by Holliman and Reynolds (2002), 95 percent of white sturgeons exposed to electronarcosis recovered immediately. Juvenile lake and shortnose sturgeon immobilized with 80 mg/L of MS-222 took a significantly longer time to orient than control fish or fish immobilized with electricity for five or thirty minutes (Henyey et al. 2002). 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).

In previous studies using electronarcosis, minimal adverse effects have been observed. Since 2004 researchers have used electronarcosis on the Potomac River and Chesapeake Bay to anesthetize shortnose and Atlantic sturgeon with no adverse effects reported (Kahn and Mohead 2010). In another study in South America, researchers followed similar methods and reported similar results (Alves et al. 2007). Henyey et al. (2002) used electronarcosis in a lab setting and monitored shortnose sturgeon for six weeks, observing no adverse effects in that time. Furthermore, researchers under NMFS Permit No. 1549 reported several years of data showing no mortality following anesthetization with electronarcosis. In the proposed action, researchers will use low amperage direct current, as described in Henyey et al. (2002). Kahn and Mohead (2010) support this methodology when performing electronarcosis.

We expect shortnose and Atlantic sturgeon undergoing electronarcosis to respond similarly to the research discussed 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 and if utilizing the methodology described by Henyey et al. (2002) and endorsed by Kahn and Mohead (2010), there is very little chance of mortality or harmful injury. Therefore, using electronarcosis as proposed is not likely to reduce the fitness of individual Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon or reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.10 Internal acoustic tagging

Survival rates after implanting transmitters in sturgeon are high. Collins et al. (2002a) evaluated four methods of radio transmitter attachment on shortnose sturgeon, inclusive of the technique that would be used in the proposed action (i.e., ventral implantation of a transmitter with a coiled antenna). They found 100 percent survival and retention over their study period. DeVries (2006) reported movements of eight male and four female (≥768 mm total length) shortnose sturgeon internally radio-tagged between November 14, 2004 and January 14, 2005. 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 four months. Periodic checks for an additional two months also showed no movement. Although there were no known mortalities directly attributable to the implantation procedure; the status of the three unrelocated individuals was unknown (DeVries 2006). 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. However, it does not appear that expulsion causes further complications or death in fish (Lacroix et al. 2004; Lucas 1989; Moore et al. 1990).

Thorstad et al. (2000) studied the effects of telemetry transmitters on swimming performance of adult farmed Atlantic salmon and found that swimming performance and blood physiology of adult Atlantic salmon (1021 to 2338 g, total body length 45 to 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.

Tag weight relative to fish body weight is an important factor in determining the effects of a tag (Jepsen et al. 2002). Kahn and Mohead (2010) suggest that generally, heavier tags reduce growth or affect the swimming ability of tagged fish. Several studies have shown adverse effects on fish when they are tagged with transmitters exceeding 2 percent of their body (Jepsen et al. 2003). For example, Lefrancois et al. (2001) measured the oxygen consumption of European sea bass (*Dicentrarchus labrax*) tagged with a dummy transmitter with weight representing 0, 1, and 4 percent of the animal. The researchers found that when the weight of the transmitter reached 4 percent, the fish consumed significantly more oxygen, required more energy to breath, and diverted energy from other life functions such as growth and swimming ability. Specifically, fish with heavier tags were observed not able to appropriately regulate their buoyancy. 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 percent 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. Sutton and Benson (2003) demonstrated that fish with medium and large external transmitters exhibited lower growth than fish with small transmitters or the control group (Sutton and Benson 2003). Adams et al. (1998) found that 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 to 23 days after tagging. However, there are exceptions where exceeding this tag to bodymass ratio has not resulted in any observable adverse impacts (Jepsen et al. 2003). For example, Jepsen et al. (2003) compared data on Chinook salmon and steelhead migrating in the Columbia River and found that migration rates were the same between fish with tags representing 2 to10 percent of their body weight (i.e., radio transmitters) versus fish with tags representing <1 percent of their body weight (i.e., PIT tags). Kahn and Mohead (2010) recommend not exceeding a tag to body weight ratio of 1.25 percent in water and 2 percent in air for all tags cumulatively.

When surgically implanting internal acoustic tags, the researchers will follow the methods recommended by Kahn and Mohead (2010) including not surgically implanting internal telemetry tags when water temperatures are greater than 27^{o}C or less than 7^{o}C and ensuring the total weight of all tags will not exceed 2 percent of the sturgeon's body weight. Additionally, the researchers will be disinfecting surgical equipment and changing gloves between surgeries to avoid disease transmission and ensuring proper closure of the surgical incision. Implementing these measures is expected to minimize potential adverse effects of this activity.

Based on the information presented above and the measures that will be taken to minimize potential adverse effects to individual sturgeon, we expect shortnose and Atlantic sturgeon survival rates following surgical implantation of internal acoustic tags to be high. Additionally, we expect that the surgical wound would heal normally, but acknowledge that adverse effects of these proposed tagging procedures could include handling discomfort, hemorrhaging at the site of incision, infection from surgery, or affected swimming ability. 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). 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 individual Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon. Therefore, this activity is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.11 Gastric lavage

Serious injury and mortality has occurred when lavaging sturgeon using protocols developed during the late 1990s. These techniques used a less flexible aquarium tubing than will be used in the proposed research. This prevented the tubing from bending with the stomach, ultimately resulting in a swimmer bladder filled with water and damage to the alimentary canal and stomach (Kahn and Mohead 2010). The proposed action under Permit 19331 will use the methods described by Haley (1998), including anesthetizing the sturgeon to relax the gut, using a flexible polyethylene tube, and irrigating the individual’s gills with ample oxygenated water flow. Using this methodology, gastric lavage is now considered safe and effective for use on sturgeon (Kahn and Mohead 2010). Several researchers have reported successful gastric lavage work in the field with no immediate mortalities (Brosse et al. 2002; Collins et al. 2008; Guilbard et al. 2007; Haley 1998; Nilo et al. 2006; Savoy 2007; Savoy and Benway 2004).

Some researchers have also expressed concern that delayed mortality and other risks may make the procedure not worth the risk. However, laboratory tests by several researchers monitoring post-lavage survival have resulted in no instances of delayed mortality (e.g., Brosse et al. 2002; Wanner 2006). Brosse et al. (2002) reported all lavaged Siberian sturgeon were in poorer condition than control fish after 60 days due to weight loss. However, Collins et al. (2008) observed different results, recapturing lavaged fish over 70 days apart and documenting normal weight gains in the intervals between capture and re-lavage. Further, Wanner (2006) (pallid sturgeon, *Scaphirhynchus albus*) showed results that indicate lavage did not negatively influence sturgeon growth.

Further review of the literature shows gastric lavage on sturgeon with Haley’s methodology, as described above, 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) was 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. 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 et al. (2006) also compared responses of shortnose in captivity to wild fish and found no weight difference from their response to lavage. 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.

Since the researchers will be following the procedures outlined in Haley (1998), we do not expect mortalities or serious injuries to result from gastric lavage procedures. Ruptured bladders and bleeding from the vent were only observed in a study that used rigid aquarium tubing and no anesthesia (Sprague et al. 1993). Finally, the weight loss of Siberian sturgeon in the Brosse et al. (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. The applicants have been previously authorized to conduct gastric lavage on sturgeon and have performed the procedure with no mortalities or apparent ill effects that have been reported. Based on our review of available information, the training and experience of the applicants, and precautions that will be taken to minimize impacts, we believe that gastric lavage is not likely to reduce the fitness of individual sturgeon in the Delaware River or reduce the viability of the New York Bight DPS of Atlantic sturgeon as listed under the ESA.

6.3.12 Fin ray clip

Kohlhorst (1979) first reported the potential adverse effects of pectoral fin-ray sampling, including mortality of white sturgeon during a mark recapture study. This result triggered additional laboratory research by Collins (1995) and Collins and Smith (1996). Using methods to remove the entire ray from the base(as opposed to a small section as is being proposed in Permit No. 19221 and No. 19642), Collins and Smith (1996) 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. 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 the leading fin-ray removed months earlier). Concluding this regrowth could be due to slower growth of mature, adult fish and possibly become detrimental to the sturgeons' health, their team no longer samples fin spines from larger, adult sturgeon (Kahn and Mohead 2010).

The researchers would use the fin ray clipping methodology outlined in Kahn and Mohead (2010) on juvenile Atlantic sturgeon. Using this methodology, the fin-ray sampling procedure is not expected to have a substantial 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. Therefore, based on our review of available information and the precautions that will be taken to minimize impacts, we believe that fin ray clipping is not likely to reduce the fitness of individual sturgeon in the Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast, or reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.13 Hydro-acoustic testing

Under Permit No. 19642, selected shortnose and Atlantic sturgeon under Permit No. 19331 would be scanned using fishery hydro-acoustic and/or sonar equipment as part of an evaluation of technologies for remote detection and identification of sturgeon (Brundage and Jung 2009; Nealson and Brundage 2007). Sturgeon tested with hydro-acoustics/sonar would be scanned while still in nets or while tethered using soft-fabric (nylon or cotton) mesh sleeves for up to two hours. The proposed methods will follow Brundage and Jung (2009), where the researchers captured sturgeon and three other non-listed fish species for hydro-acoustic data collection using anchored bottom-set gill nets. There are two stressors we examined for this type of testing and methodology. The first hydro-acoustic testing stressor we examined was possible effects to the sturgeon from sonar. The second hydro-acoustic testing stressor we examined was the potential stress caused by tethering sturgeon in the soft nylon or cotton mesh sleeves for up to two hours. Hydro-acoustics are frequently used for remotely locating fish for research and fishing, and it has been demonstrated that fish do not hear within common ranges used. Many studies have explored the use of sonar technology to identify sturgeon species underwater (Auer and Baker 2007; Flowers and Hightower 2015; Hartman and Nagy 2006; Nealson and Brundage 2007; Qiao et al. 2006). Studies show that, with few exceptions, fish cannot hear sounds above about 3 to 4 kHz, and the majority of species are only able to detect sounds to 1 kHz or even below (Popper 2008). Tethering shortnose sturgeon in mesh sleeves is similar to what the fish would experience for net capture. They will be held underwater for no more than two hours and NMFS netting protocols would be adhered to. The proposed permit calls for the use of a broadband sonar system operating at 110 to 220 kHz. Due to the studies which show that most fish cannot hear sounds above 3 to 4 kHz (Martin and Popper 2016), we do not believe that shortnose sturgeon will be affected by this frequency. Since tethering of shortnose sturgeon under the permit will be conducted according to netting conditions, we believe that tethering effects would be similar to netting effects as explained in the netting response section

Therefore, based on our review of available information and the precautions that will be taken to minimize impacts, we believe that hydro-acoustic testing is not likely to reduce the fitness of individual sturgeon in the Delaware River or reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.14 Recaptures

We anticipate potential recaptures to incur similar effects and responses to the stressors discussed above. By using the proper research techniques described in the permit, recaptures are not expected to reduce the fitness of individual Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay, and the Atlantic Coast sturgeon. Therefore, this activity is not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.15 Incidental mortality

Permit No. 19331 and No. 19642 would authorize research related incidental mortality to shortnose and the New York Bight DPS and Chesapeake Bay DPS of Atlantic sturgeon over the five-year permitting period. This is due to NMFS' reasonable anticipation that sturgeon might overdose from anesthesia or experience severe injury or mortality from netting/capture, anesthesia, or other methods (described in the *Effects* section above). Each researcher has maintained a record of verifiable mortality in previous authorized research in the same action area. Researchers under Permit No. 19331 anticipate two unintentional mortalities per year of both shortnose and New York Bight DPS Atlantic sturgeon species (of any life stage), but not more than one adult of each species during the five years of the permit. Researchers under Permit No. 19642 anticipate one shortnose sturgeon unintentional mortality per year and two Chesapeake Bay DPS Atlantic sturgeon unintentional mortalities per year (of any life stage), but not more than one adult of each species during the five years of the permit. The applicant would be required to document any lethal takes of Atlantic and shortnose 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 19 active other NMFS-issued permits allowing take of shortnose and New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon on the east coast of the United States. Of these permits, four scientific research permits are issued pursuant to Section 10(a)(1)(A) of the ESA, authorizing research on sturgeon in the Delaware River and Estuary, and one in the Chesapeake Bay.

Authorizing incidental mortality throughout the life of the permit would ensure NMFS documentation and specimen preservation of the sturgeon. Should an incidental mortality or serious harm occur, the Permit Holder must suspend all authorized activities and contact the Chief, NMFS Permits and Conservation Division as soon as possible, but no later than two business days. The Permit Holder must also submit a written incident report. The Permits and Conservation Division may grant authorization to resume permitted activities based on review of the incident report and in consideration of all other permit conditions.

Permit No. 19331 would authorize the incidental mortality of two shortnose sturgeon in the Delaware River and estuary annually (any life stage, but only one adult mortality will be authorized over the life of the permit). The Delaware River population of shortnose sturgeon is one of the larger and healthier stocks within its range. Brundage and Herron (2003) estimated the Delaware River shortnose sturgeon spawning population to total 12,000 adults (range of 6,408 to 14,080). The anticipated impact of two shortnose sturgeon mortalities per year of any life stage, but only one adult over the lifetime of the five year permit, on the Delaware River population would be small based on the 2003 abundance estimate, or 0.017 percent. Currently, one other scientific research permit authorizes incidental mortality of shortnose sturgeon in the Delaware River and estuary: Permit No. 19255, issued to the Delaware Division of Natural Resources and Environmental Control. Permit No. 19255 authorizes the incidental mortality of one shortnose sturgeon annually, but no more than two adults over the life of the permit.

Permit No. 19642 would authorize the incidental mortality of one shortnose sturgeon of any life stage in the Chesapeake Bay estuary per year, but only one adult over the life of the permit. Currently, there are no other scientific research permits that authorize incidental mortality of shortnose sturgeon in the Chesapeake Bay estuary. The current population estimate of shortnose sturgeon in the Chesapeake Bay and its tributaries is unknown. It is unknown whether or not shortnose sturgeon reproduce in the Chesapeake Bay, and genetic analysis indicate that the shortnose sturgeon in the Chesapeake Bay/Delaware River compromise a metapopulation (King et al. 2014b). There is some evidence that individuals tagged in the Delaware River travel to the Chesapeake Bay through the Chesapeake and Delaware Canal (SSSRT 2010). While there is no current population estimate, and the Maryland Reward Program has documented about 80 shortnose sturgeon up to 2008 (SSSRT 2010). The anticipated impact of up to five shortnose sturgeon mortality of any life stage, but only one adult over the lifetime of the five year permit, on the Chesapeake Bay population is anticipated to be small.

The majority of individuals proposed for capture and additional research activities are juveniles. None of the more invasive procedures which require anesthetization and increase risk of mortality will be employed on adult shortnose sturgeon. Therefore, it is much more likely that any unintentional mortality would be of juvenile fish, which are more abundant than spawning adults. Juvenile shortnose sturgeon are more abundant than spawning adults, meaning that the loss of a juvenile fish due to an unintentional mortality would have comparatively less of an impact on the overall population than a spawning adult, which has greater reproductive potential. Both permits restrict the amount of unintentional mortality for adult shortnose sturgeon to one over the life of the entire permit (i.e., five years). For these reasons, the anticipated impact of two annual shortnose sturgeon mortalities on the Delaware River population and one annual in the Chesapeake Bay population over the life of the five year permit is not expected to adversely affect the overall population and we conclude that the allowance of one incidental mortality per year of an adult for each permit throughout the life of the permit would not appreciably reduce the likelihood of the survival and recovery of the Delaware River and Chesapeake Bay shortnose sturgeon populations. Therefore, it is unlikely to reduce the likelihood of the survival and recovery of the shortnose sturgeon population as listed under the ESA.

For the purposes of this opinion, we considered the NEAMAP estimate of ocean population abundance resulting from the 50 percent catchability rate (67,776 individuals; Table 13), as the best available information on ocean population of Atlantic sturgeon in the ocean (Kocik et al. 2013b). Additionally, we can estimate that 10.7 percent of this population abundance (calculated from Table 2 of Kocik et al. 2013a) is comprised of adults, or individuals greater than 150 cm (approximately 7,252 individuals). We then considered an estimate from a mixed stock analysis of the New York Bight DPS of Atlantic sturgeon to encompass 54.6 percent subadult and adult individuals and 20.6 percent of Chesapeake Bay DPS (See Table 2 in Wirgin et al. 2015a). Thus, of the one adult intentional mortality permitted over the five years of each permit, we can estimate that 0.025 percent of adult New York Bight DPS of Atlantic sturgeon under Permit No. 19331 and 0.067 percent of adult Chesapeake Bay DPS of Atlantic sturgeon under Permit No. 19642, will be killed by the proposed actions under these permits. Currently, one other scientific research permit (No. 16547) authorizes incidental mortality of Atlantic sturgeon in Chesapeake Bay (three individuals over the life of the permit). Permit No. 19255 authorizes one Atlantic sturgeon incidental mortality per year for research activities in the Delaware Bay estuary.

It is also worth noting that the majority of individuals proposed for capture and additional research activities are juveniles. Further, none of the more invasive procedures which require anesthetization and increase risk of mortality will be employed on adult Atlantic sturgeon. Therefore, it is much more likely that any unintentional mortality would be of juvenile fish. Juvenile Atlantic sturgeon are more abundant than spawning adults, meaning that the loss of a juvenile fish due to an unintentional mortality would have comparatively less of an impact on the overall population than a spawning adult, which has greater reproductive potential. We do not have an estimate of the absolute abundance of juvenile Atlantic sturgeon in the New York Bight DPS and Chesapeake Bay DPS. However, considering basic fish biology (i.e., there are more juveniles than adults) and comparing the number of juvenile Atlantic sturgeon in the Altamaha River (1,000 to 2,000 individuals; Schuller and Peterson 2006) to the number of spawning adults in the same river (343 individuals; Schueller and Peterson 2010), we expect significantly more juvenile Atlantic sturgeon in the Delaware River and Chesapeake Bay, than adults. Therefore, the anticipated impact of one adult Atlantic sturgeon mortality (but up to two juveniles or subadults annually) on the Delaware River population and one adult (but up to two juveniles or sub-adults annually) on the Chesapeake Bay population over the life of the five year permit is expected to be insignificant to the overall population and we conclude that the allowance of one incidental mortality under each permit of an adult Atlantic sturgeon over the life of the five year of both permits is unlikely to reduce the likelihood of the survival and recovery of the Delaware River, York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, the Chesapeake Bay sturgeon populations. Therefore, it is unlikely to reduce the likelihood of the survival and recovery of the New York Bight DPS and Chesapeake Bay DPS of Atlantic sturgeon and as listed under the ESA.

6.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). 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.

During this consultation, NMFS searched for information on future state, tribal, local, or private actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline, which we expect will continue into the future. An increase in these actions could result in an increased effect on ESA-listed species; however, the magnitude and significance of any anticipated effects remain unknown at this time.

6.5 Integration and Synthesis

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 (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992a). 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.

The *Status of Listed Resources* described the factors that have contributed to the reduction in population size for the species considered in this opinion. Threats to the survival and recovery of these species include, but are not limited to, fisheries interactions, vessel traffic, dredging, power plant operations, and pollution. NMFS expects that the current natural and anthropogenic threats described in the *Environmental Baseline* will continue. We did not find any likely non-Federal future actions in the Action Area that could affect the species considered in this opinion beyond those described in the *Environmental Baseline*.

Under the proposed permits, listed sturgeon would be exposed to the following potential stressors: capture, handling for procedures and measurement, genetic tissue sampling, PIT tagging, T-bar tagging, JSAT tagging, anesthesia, internal acoustic tagging, gastric lavage, fin ray clipping, hydro-acoustic testing, recaptures, and incidental mortality. As described in Section 6.3, with the exception of rare instances of incidental mortality, and the lethal take of early life stage sturgeon, stressors associated with the proposed action are not likely to reduce the fitness of individual fish, and would not affect the viability of Delaware River and Chesapeake Bay sturgeon populations. By extension, stressors associated with the proposed action that do not result in mortality are not likely to reduce the viability of the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA. The proposed permit No. 19642 would authorize the incidental mortality of one shortnose and one Atlantic sturgeon mortality annually of any life stage, but no more than one adult shortnose sturgeon and one adult Atlantic sturgeon over the five-year term of the permit. As described in Section 6.3.13, we determined that the authorized instances of incidental mortality would not appreciably reduce the likelihood of the survival and recovery of the Delaware River Atlantic or shortnose sturgeon populations. Therefore, these instances of incidental mortality are unlikely to reduce the viability of the shortnose sturgeon or the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon as listed under the ESA.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects,* stressors resulting from the issuance of Permit No. 19331 to Harold Brundage of ERC, Inc. and Permit No. 19642 to Jason Kahn for research on shortnose sturgeon and the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon, would not be expected to appreciably reduce the likelihood of the survival or recovery of these species in the wild by reducing their reproduction, numbers, or distribution.

7 CONCLUSION

During the consultation, we reviewed the current status of shortnose sturgeon and the Atlantic sturgeon, including the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon. We also assessed the *Environmental Baseline* within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects. Our regulations require us to consider, using the best available scientific data, effects of the action that are “likely” and “reasonably certain” to occur rather than effects that are speculative or uncertain. See 50 C.F.R. § 402.02 (defining to “jeopardize the continued existence of” and “effects of the action”). For the reasons set forth above, and taking into consideration the best available scientific evidence documented throughout this opinion, we conclude that the issuance of Permit No. 19331 to Harold Brundage of ERC, Inc. for research in the Delaware River and estuary, and No. 19642 to Jason Kahn for research in the Chesapeake Bay, surrounding tributaries, and the Atlantic Ocean, on Atlantic and shortnose sturgeon is unlikely to lead to any fitness consequences to any individuals, with the exception of rare instances of incidental mortality and the lethal take of early life stage sturgeon. Additionally, we concluded that authorized instances of incidental or intentional mortality would not appreciably reduce the likelihood of the survival and recovery of the Delaware River and Chesapeake Bay Atlantic or shortnose sturgeon populations. Therefore, it is NMFS' opinion that the issuance of Permit No. 19331 and No. 19642 is likely to adversely affect, but is not likely to jeopardize the continued existence of shortnose sturgeon or the New York Bight DPS, Chesapeake Bay DPS, Carolina DPS, South Atlantic DPS, and Gulf of Maine DPS of Atlantic sturgeon, or to destroy or adversely modify the proposed Atlantic sturgeon designated critical habitat.

8 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA 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 NMFS 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. 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 Sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

As discussed in the accompanying opinion, only the species targeted by the proposed research activities would be affected as part of the intended purpose of the proposed action. Therefore, the NMFS does not expect the proposed action would incidentally take threatened or endangered species.

9 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
- help implement recovery plans
- develop information

We recommend the following conservation recommendation, which would provide information for future consultations involving the issuance of permits that may affect listed sturgeon as well as reduce harassment related to the authorized activities:

- We recommend that the Permits and Conservation Division continue to develop a programmatic approach to research permit consultations on a species-specific or geographic basis, or other programmatic approach. A programmatic approach to research permit consultations would allow for a better understanding of all proposed research efforts and their effects to populations and would expedite issuance of individual research permits.

In order for NMFS's ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, listed species or their habitats, the Permits Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

10 REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed issuance of Permit No. 19331 to Harold Brundage of Environmental Research and Consulting, Inc., for research on Atlantic and shortnose sturgeon in the Delaware River and estuary, and of Permit No. 19642 to Jason Kahn for research on Atlantic and shortnose sturgeon in the Chesapeake Bay, the York, Rappahannock, Potomac, and Susquehanna Rivers, their tributaries, and the Atlantic Coast. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the Permit Holder and NMFS' Permits Division must immediately contact the ESA Interagency Cooperation Division, Office of Protected Resources.

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