NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION

Action Agencies: Permits and Conservation Division of the Office of Protected Resources, National Oceanic and Atmospheric Administration's National Marine Fisheries Service

Activity Considered: NMFS Permits and Conservation Division's issuance of a Permit (No. 19255) to the Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, for research on Atlantic and shortnose sturgeon in the Delaware River 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: Perry Gayaldo

for Donna S. Wieting
Director, Office of Protected Resources

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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), 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 (ITS) 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.

The 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.

1.1 Consultation History

On January 15, 2015, NOAA's National Marine Fisheries Service (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 a permit for research (No. 19255) to conduct scientific research activities on shortnose sturgeon (*Acipenser brevirostrum*) in the Delaware River and Estuary.

On January 27, 2015 the NMFS ESA Interagency Cooperation Division requested additional information from the NMFS Permits Division regarding the proposed research methodology.

On January 29, 2015 the NMFS Permits Division sent a revised draft permit to the NMFS ESA Interagency Cooperation Division.

On July 10, 2015, the NMFS Permits Division revised the proposed action to include research activities on New York Bight Distinct Population Segment (DPS) Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*).

On November 16, 2015, the NMFS Permits Division sent a revised draft permit to NMFS ESA Interagency Cooperation Division.

On November 16, 2015, the NMFS ESA Interagency Cooperation Division deemed the application complete and initiated formal consultation with the NMFS Permits Division.

From November 18 through December 1, 2015, the NMFS ESA Interagency Cooperation Division requested additional information from the NMFS Permits Division regarding the research methodology and requested incidental mortality of sturgeon.

On December 1, 2015, the NMFS Permits Division sent a revised draft permit to the NMFS ESA Interagency Cooperation Division.

On December 7 and 8, 2015, the NMFS ESA Interagency Cooperation Division communicated with the NMFS Permits Division regarding the number of recaptures for Atlantic and shortnose sturgeon for the permit.

2 DESCRIPTION OF THE PROPOSED ACTION

The NMFS Permits Division proposes to issue a permit (No. 19255) to the Delaware Department of Natural Resources and Environmental Control, Fish and Wildlife Division (DNREC) for scientific research pursuant to section 10(a)(1)(A) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.). The proposed activities involve purposeful harassment, harm, wounding, trapping, capture, or collection ("take[1]") of the endangered shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*) for scientific purposes.

[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."

Once effective, this permit would renew similar research authorized in the Delaware River by existing Permit No. 14396 for shortnose sturgeon, and would replace Permit No. 16431 for Atlantic sturgeon. If issued, the permit would be valid for five years from the date of issuance, with DNREC as Principal Investigator (PI).

2.1 Proposed Activities

The activities proposed under this permit are to locate and document early juvenile shortnose sturgeon and Atlantic sturgeon nursery areas in the Delaware River (river kilometer (rkm) 0 to 216), to assess individual movement patterns, seasonal movements, home ranges, nursery areas, and over-wintering habitat use of juvenile life stages through the use of passive telemetry. The permit would be valid for 5 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 DNREC researchers. Under the proposed research, each animal would only be captured (taken) once. The requested take of shortnose and Atlantic sturgeon is based on prior Delaware River sampling conducted since 1991 and research objectives of the DNREC over the next five years.

Table 1. Proposed "takes" of listed sturgeon during DNREC's research activities in the Delaware River and Estuary, Permit No. 19255.

Species	Life stage	Expected take	Take Action	Procedure	Details
Shortnose sturgeon	Juv.	50*	Capture/ Handle/ Release	Mark ,Floy T-bar; Mark, Passive Integrated Transponder (PIT) tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Capture up to 50 juveniles (≤500 mm total length) per year, but no more than 150 during the life of the five year permit
	Juv.	15	Capture/ Handle/ Release	Anesthetize; Instrument, internal (e.g., VHF, sonic); Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Juvenile ≤ 500 mm TL; Would not sonic tag animals less than 300 mm or if the tag exceeds 2% of body weight
	Adult/ Juv.	1	Unintentional mortality	Unintentional mortality	Up to 1 unintentional mortality of an adult/sub-adult/juvenile annually, but no more than 1 adult (≥500 mm FL) during life of the 5 year permit
	Adult/ Subadult	10	Capture/ Handle/ Release	Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Capture up to 10 adult or subadult animals (>500 mm total length) per year
Atlantic sturgeon (New York Bight DPS)	Juv.	175*	Capture/ Handle/ Release	Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Capture by gill nets (juveniles ≤600 mm total length)

Species	Life stage	Expected take	Take Action	Procedure	Details
	Adult/ Subadult	10	Capture/ Handle/ Release	Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Capture up to 10 adults or subadults (>600 mm total length)
	Juv.	30	Capture/ Handle/ Release	Anesthetize; Instrument, internal (e.g., VHF, sonic); Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Juveniles ≤600 mm total length, would not sonic tag animals less than 300 mm or if the tag exceeds 2% of body weight
	Juv.	30	Capture/ Handle/ Release	Anesthetize; Lavage; Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Weigh	Juveniles (≤600 mm total length) will be subject to lavage procedures
	Juv.	30	Capture/ Handle/ Release	Anesthetize; Mark, Floy T-bar; Mark, PIT tag; Measure; Photo/ Video; Sample, fin clip; Sample, fin ray clip; Weigh	Juveniles (≤600 mm total length) will be subject to fin ray clipping
	Adult/ Juv.	1	Unintentional mortality	Unintentional mortality	1 unintentional mortality of an adult/ subadult/juvenile annually, but no more than 1 adult (≥500mmFL) during the life of the 5 year permit

*Each captured individual may be recaptured up to two times annually.

Under existing permit number 14396, two shortnose sturgeon were captured between 2010 and 2014, but no incidental mortalities were reported. Under existing permit 16431, 191 Atlantic sturgeon were captured from April 2012 to April 2015 (98% of captures were from April 2014 to April 2015), but no incidental mortalities were reported. Biological opinions were written on the issuance of these permits. The biological opinion for the issuance of permit number 14396 concluded that issuance of the permit was likely to adversely affect shortnose sturgeon, but was not likely to jeopardize the continued existence of the species (NMFS 2010). The biological opinion for the issuance of permit number 16431, similarly concluded that issuance of the permit was likely to adversely affect the New York Bight DPS Atlantic sturgeon, but was not likely to jeopardize the continued existence of the species (NMFS 2012).

2.1.1 Gill Netting/Capture

Sampling would begin March 1 of each year, however sampling effort would primarily target early juvenile Atlantic and shortnose sturgeon from October 1 until December 31 (up to 10 sampling events per month), or until water temperature reaches 0 degrees Celsius (°C). Though they would also be authorized to use anchored gill nets, generally the researchers would use drifting monofilament nylon gillnets. 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 prior to slack tide, perpendicular or diagonal to the tidal current, and tended closely by DNREC 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).

Table 2. Summary of gill netting conditions.

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

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.

2.1.2 Recaptures

The researchers do not anticipate a high number of recaptures of either Atlantic or shortnose sturgeon based on the numbers of recaptures during prior years of sturgeon research in Permits No. 16431 (NMFS 2012) and 14396 (NMFS 2010). However, because sampling efforts would increase over previous years, additional sturgeon recaptures may be observed. In anticipation of this, DNREC will be permitted to capture individual juvenile Atlantic and shortnose sturgeon up to three times annually (one initial capture, followed by two potential recaptures). 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.

2.1.3 Sampling Techniques

2.1.3.1 General Handling

The proposed activities would include the general handling of all captured Atlantic and shortnose sturgeon. Individuals would be weighed, measured to total length (TL), examined for tags, marked with PIT and T-bar tags, sampled (i.e., genetic fin clip), photographed, and released (

Table 1). A subset of these individuals would undergo additional handling as described below.

Once captured, sturgeon would be held temporarily in boat-side net pens measuring approximately 121 cm long x 91 cm wide x 91 cm deep. Additional net pens or live cars would be onboard to accommodate excess holding of sturgeon and/or bycatch. Handling of fish would be kept to a minimum and fish would not be held for more than 2 h in a live car, with the norm being less than 30 min.

Once recovered, sturgeon would be transferred to an onboard processing station and holding tanks for weighing, measuring, and further sampling. To minimize handling effects, sturgeon would be moved and handled by researchers using latex gloves, and when in onboard holding tanks, sturgeon would be immersed in a continuous stream of water supplied by a pump-hose assembly mounted over the side of a research vessel. Dissolved oxygen would be supplemented with compressed oxygen to ensure the dissolved oxygen concentration does not fall below saturation as stated in Table 2. Shortnose and Atlantic sturgeon would be measured on a flat wet board for fork length (FL) and total length in mm, weighed (g) by a hanging scale and a wet mesh sling. 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.

2.1.3.1.1 Genetic 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 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 tissue sample would be collected from the trailing margin of the pectoral fin using sharp sterilized scissors. Tissue samples would be preserved in individually labeled vials containing 95% 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. Some of the genetic tissue sample material would also be retained by DNREC.

2.1.3.1.2 Marking and Tagging with PIT and T-bar 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 would insert 8 mm PIT tags in juvenile Atlantic or shortnose sturgeon measuring between 250 mm and 350 mm total length. Larger sturgeon would receive 11.9 mm PIT tags. 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 T-bar tags would be inserted in animals measuring 350 mm total length or above for external identification. 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). When inserting numbered T-bar tags, they 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.

2.1.3.2 Anesthesia

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

2.1.3.2.1 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 would be fully trained and experienced in use of MS-222 for anesthetizing sturgeon.

2.1.3.2.2 Optional Anesthesia with Electro-narcosis (EN)

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 EN prior to anesthetizing sturgeon with EN.

2.1.3.3 Internal Acoustic Tagging

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

Juvenile sturgeon of either species selected for acoustic tagging would be implanted with a transmitter of appropriate size (not to exceed 2% body weight in air to ensure normal mobility) (e.g., Vemco: V7-4L, 69 kHz, V8-4H, 69kHz or V9-4H, 69 kHz). Prior to tag implantation, the individual would be anaesthetized using 50 to 150 mg/L of MS-222. 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) and Fox et al. (2000).

The transmitter and all surgical instruments would be sanitized immediately prior to use and the incision site cleansed. A ventral incision would be made anterior to the pelvic fins, parallel and adjacent to the ventral midline where the body width is greatest. The incision would be just large enough for the transmitter to be inserted. The incision would be closed using sterile resorptive suture material. To ensure proper closure, a single interrupted suturing technique would be applied. Surgery to implant transmitters would only be attempted when fish are in excellent condition and would not be attempted on pre-spawning fish in spring or fish on the spawning ground, 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.

2.1.3.4 Gastric Lavage (Atlantic Sturgeon diet study)

The stomach contents of an additionally selected 30 juvenile 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 50 to 100 mg/L of MS-222 or EN to relax the fish prior to the procedure. Using a flexible polyethylene tube having a 2 mm outer diameter, 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. 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 from 7 to 11 min (Collins et al. 2008). No other invasive procedure would be performed on fish undergoing gastric lavage,

2.1.3.5 Fin Ray Clip (Atlantic Sturgeon Aging Study)

An additionally selected set of 30 juvenile (<600 mm) Atlantic sturgeon would be selected annually for fin ray sectioning to calculate age. The following methods would be used to collect the samples. Under light sedation with MS-222 or EN, 2 cuts (1 cm deep) would be made into the leading edge of pectoral spine with snips. One cut would be about 1.5 cm from the terminus of the pectoral fin ray and the other about 2.5 cm from the terminus. Pliers would then be used to break out the 1 cm by 1 cm section of spine. The sample would then be placed in an envelope and allowed to air-dry for several days or weeks and later it is cut into thin slices (usually about 0.5 to 2 mm thickness) using a double bladed or jeweler's saw (Collins et al. 2008). The sections are then mounted for reading using any number of materials including clear glue, fingernail polish, cytosel, or thermoplastic cement.

2.1.3.6 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 5 min. Handling time for sturgeon not receiving an anesthetized procedure should be less than 2 min with recovery under 30 seconds. Researchers were trained in these techniques by the US Fish and Wildlife Service.

2.1.3.7 Tracking Telemetry

After juvenile Atlantic and shortnose sturgeon implanted with acoustic transmitters are released, their movements would be monitored using both active and passive tracking techniques. Active tracking would occur using a VEMCO® VR100 receiver and 2 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. These receivers are attached to United States Coast Guard (USCG) Aids to Navigation (ATON) buoys. Sampling areas may be modified in the future depending on results obtained from tracking sturgeon movement and habitat use.

2.1.3.8 Incidental Mortality or Harm

The NMFS Permits Division proposes to authorize one unintentional mortality per year of each sturgeon species (of any life stage), but not more than one adult (≥500 mm) of each species during the 5 years of the permit. If a greater incidence of mortality or serious injury should occur, NMFS, 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 NMFS 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 Permit Conditions

The objectives of the permitted activity, as described in the application, are to document nursery areas, individual movement patterns, seasonal movements, home ranges, and habitat usage of two protected species[2], juvenile shortnose sturgeon (*Acipenser brevirostrum*) and juvenile Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) [hereinafter, sturgeon], in the Delaware River and Bay. The proposed permit contains several terms and conditions intended to minimize

[2] "Protected species" include species listed as threatened or endangered under the ESA, and marine mammals.

potential adverse effects of research activities on ESA-listed sturgeon. The following terms and conditions developed by the NMFS Permits and Conservation Division are included in the draft permit (please refer to the permit document for a complete list of terms and conditions).

Terms and Conditions

The activities authorized herein must occur by the means, in the areas, and for the purposes set forth in the permit application, and as limited by the Terms and Conditions specified in this permit, including attachments and appendices. Permit noncompliance constitutes a violation and is grounds for permit modification, suspension, or revocation, and for enforcement action.

A. Duration of Permit

1. Personnel listed in Condition C.1 of this permit (hereinafter "Researchers") may conduct activities authorized by this permit for 5 years from the permit issuance. This permit expires on the date indicated and is non-renewable. This permit may be extended by the Director, NMFS Office of Protected Resources, pursuant to applicable regulations and the requirements of ESA.

2. Researchers must immediately stop permitted activities and the Permit Holder must contact the Chief, NMFS Permits and Conservation Division (hereinafter "Permits Division") for written permission to resume:

   a. If serious injury or mortality[3] of protected species reaches that specified in Appendix 1 of the permit.

   b. If authorized take[4] is exceeded, including accidental takes of protected species not listed in this permit.

3. The Permit Holder may continue to possess biological samples[5] acquired[6] under this permit after permit expiration without additional written authorization, provided the samples are maintained as specified in this permit.

B. Number and Kind(s) of Protected Species, Location(s) and Manner of Taking

1. The table in Appendix 1 of the permit outlines the number of protected species, by species and stock, authorized to be taken, and the locations, manner, and time period in which they may be taken.

2. Researchers working under this permit may collect visual images (*i.e.*, any form of still photographs and motion pictures) as needed to document the permitted

[3] This permit does allow for unintentional serious injury and mortality caused by the presence or actions of researchers up to the limit indicated in

Table 1.

[4] Under the ESA, a take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to do any of the preceding.

[5] Biological samples include, but are not limited to: carcasses (whole or parts); and any tissues, fluids, or other specimens from live or dead protected species; except feces, urine, and spew collected from the water or ground.

[6] Authorized methods of sample acquisition are specified in Appendix 1of the permit.

activities, provided the collection of such images does not result in takes of protected species.

3. The Permit Holder may use visual images and audio recordings collected under this permit, including those authorized in Table 1 of Appendix 1 of the permit, in printed materials (including commercial or scientific publications) and presentations provided the images and recordings are accompanied by a statement indicating that the activity was conducted pursuant to a NMFS Permit. This statement must accompany the images and recordings in all subsequent uses or sales.

4. The Chief, Permits Division may grant written approval for personnel performing activities not essential to achieving the research objectives (e.g., a documentary film crew) to be present, provided:

   a. The Permit Holder submits a request to the Permits Division specifying the purpose and nature of the activity, location, approximate dates, and number and roles of individuals for which permission is sought;

   b. Non-essential personnel/activities would not influence the conduct of permitted activities or result in takes of protected species;

   c. Persons authorized to accompany the Researchers for the purpose of such non-essential activities would not be allowed to participate in the permitted activities; and

   d. The Permit Holder and Researchers do not require compensation from the individuals in return for allowing them to accompany Researchers.

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

   a. *Netting, Holding, and Handling Conditions*

      i. Anchored gillnets may be fished in water with 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; however, at temperatures less than 7ºC, and above 27°C, research procedures must be limited to non-invasive procedures only (i.e., PIT and T-bar tag, measure, weigh, photograph, and genetic tissue clip) (Table 2).

      ii. The Permit Holder must take necessary precautions ensuring sturgeon are not harmed during captures by using appropriate gillnets, restricting gillnetting activities by decreasing net set durations as water temperature increases and dissolved oxygen concentration decreases, and following other measures outlined in "A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons (Kahn and Mohead 2010). "

      iii. Location (GPS), temperature, dissolved oxygen (D.O.), gear used (e.g., mesh size and length), soak time, species captured, and any mortalities should be measured and recorded (at the depth fished) each time nets are set to ensure appropriate values according to the conditions below.

This data must be made available to NMFS in annual reports or upon request (Appendix 4 of the permit).

iv. Drift Gillnet Netting[7]:

(1) Drift gillnets may be used on the rising or falling tide or during slack water for 30 min to 2 h, depending on the location and swiftness of the tide.

(2) Drift gillnets must be checked immediately if an obvious capture has been made or the gear has become snagged on substrate or debris.

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

v. Upon removing a non-responsive or overly stressed sturgeon from capture gear, researchers must allow the animal to recover in floating net pens or in onboard live tanks, shielding it from direct sunlight. At the discretion of the researcher, however, the animal may be minimally handled and released when recovered (Note: Researchers may PIT tag, measure, weigh, and genetic sample, or photograph an animal recovered from stress, but must not perform further research activities prior to release).

vi. To accommodate larger catches, researchers must use secondary net pen(s), having adequate manpower and equipment available (extra crews and spare net pens); overcrowded fish must either be transferred to spare net pens, or else released.

vii. While holding fish onboard, they must be held in sufficiently sized on-board live wells, allowing for total replacement of water volume every 15 min, or else held in a boat-side floating net pen. Backup oxygenation of holding tanks with compressed oxygen is necessary when working with large number of fish to minimize stress.

viii. During onboard handling, sturgeon must be supported using a sling or net; and handling should be minimized throughout the procedure using smooth rubber gloves. Sturgeon should be minimally crowded during transfer and kept in water to the maximum extent possible during processing.

ix. The maximum holding time of unstressed sturgeon after removal from capture gear until returned to the water, must not exceed two hours; however, at water temperatures > 27°C, holding time must be reduced to 30 min after removal from the capture gear.

x. The total handling time included for onboard procedures for individual

[7] The same environmental conditions applied for anchored gill nets apply for drift nets.

sturgeon must not exceed 20 min. (Note: This does not include recovery time from anesthesia or stressed condition).

xi. Prior to release, while holding vertically and immersed in river water, sturgeon should be moved front to back, aiding freshwater passage over the gills to stimulate it. The fish should be released only when showing signs of vigor and ability to swim away under its own power. A spotter should watch the fish as it is released making sure it stays submerged and does not need additional recovery.

xii. Detailed records should be kept on the recovery and other responses from capture, tagging, and other research methods, measuring the growth, condition and health of recaptured sturgeon. This information must be reported to NMFS in annual reports (See reporting conditions Section E.).

xiii. Because sturgeon are extremely sensitive to chlorine and other sanitizing solutions; if such agents are used between sampling, a thorough flushing of holding tanks would be required between sampling periods.

b. *Biological Sampling*:

i. Genetic tissue samples must be taken from all sturgeon collected by removing a small (1.0 cm^2) fin-clip from soft fin tissues using a pair of sharp scissors. NMFS recommends preserving tissue samples in individually labeled and sealed vials containing 95% ethanol (See instructions, Appendix 3c of the permit).

ii. Genetic tissue samples should be archived locally prior to submitting samples to a designated NOAA Tissue Archive, or to other locations periodically, as directed by the Permits Division or Regional Office.

iii. Records of genetic tissue collections (Appendix 3b of the permit) must be submitted to the NOAA Tissue Archive (See instructions, Appendix 3a of the permit), the Permits Division, and/or the NMFS Regional Office within 6 months of collection.

iv. The Permit Holder may receive genetic material from the NOAA Tissue Archive for research purposes described in the application by coordinating with the Permits Division, NMFS Regional Office, or alternately coordinating with the original collector of the tissue sample.

v. Refer to Section E.7, 8, and 9 for direction on proper certification, identity, chain of custody and shipping methods when transferring genetic tissue samples.

vi. Fin ray section samples (1-cm x 1-cm clip) from juvenile Atlantic sturgeon are authorized to be collected using sterilized snipping pliers or bone saws and scalpels from the pectoral fin ray while under light anesthesia (See Kahn and Mohead 2010, p.42).

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

viii. Fin ray sections may be analyzed by the Permit Holder, stored for future analyses, or sent to cooperating laboratories or individuals listed in Condition C.1 for analysis.

ix. In general, care must be used when collecting biological samples. Instruments must be sanitized or changed and gloves must be changed between sampling each fish to avoid possible disease transmission or cross contamination of sample materials.

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

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

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

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

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

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

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

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

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

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

c. *Tagging Conditions*

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

ii. PIT tags can be injected in the dorsal musculature just anterior and left of the dorsal fin. The copper antenna should be oriented upward for maximum signal strength and scanned after implantation to ensure proper tag function. If necessary, to ensure tag retention and prevent harm or mortality to smaller juvenile sturgeon, the PIT tag may also be inserted at the widest dorsal position. Alternately, researchers may also insert PIT tags under the 4th dorsal scute.

iii. Researchers may use PIT tags measuring 11.5 mm length x 2.1 mm diameter in juvenile sturgeon measuring at least 350 mm total length (TL); and PIT tags measuring 8.4 mm x 1.4 mm diameter may be used in sturgeon measuring between 250 and 350 mm TL.

iv. Numbered T-bar tags may be attached in the dorsal fin base of sturgeon measuring at least 350 mm TL by inserting the tag forward and angled slightly downward through the dorsal pterygiophores and twisted to insure attachment.

v. The rate of PIT tag and T-bar tag retention and the condition of recaptured fish at the site of tag injection should be documented during the study, and results reported to the Permits Division in annual and final reports.

vi. Surgical implantation of internal telemetry tags may only be attempted by approved researchers designated in Section C; and in only sturgeon of proper size and condition;

vii. The minimum TL of animals receiving an internal sonic tag should be greater than 300 mm TL; however, the total weight of all tags must not exceed 2% of a sturgeon's total body weight.

viii. Surgical implantation of internal telemetry tags and must not be attempted when water temperatures are greater than 27° C or less than 7° C.

ix. Surgical instruments must be changed or disinfected and gloves changed between surgeries to avoid possible disease transmission.

x. To ensure proper closure of surgical incisions to implant telemetry tags, either uninterrupted running or simple interrupted suturing techniques may be applied.

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

d. Gastric Lavage for Diet Analysis:

i. Prior to performing gastric lavage on Atlantic sturgeon juveniles individual researchers must first have had supervised training from an experienced researchers using either wild or captive sturgeon, or other close surrogate species. This training must be documented in Section C.1 of the permit.

ii. When performing gastric lavage, researchers must anesthetize sturgeon, relaxing the gut prior to penetrating the tubing to the proper position in the gut.

iii. While performing gastric lavage on Atlantic sturgeon, researchers must irrigate the sturgeons' gills with ample oxygenated water flow, insuring respiration.

e. Anesthesia (Using MS-222 or Electro-narcosis (EN)):

i. Researchers performing anesthesia on sturgeon using MS-222 or EN, must have first received supervised training on the procedures on sturgeon or another surrogate species. The Responsible Party or PI must report this training to NMFS prior to the activity.

ii. Researchers may use MS-222 for anesthetizing sturgeon at concentrations up to 150 mg/L; such solutions should be made fresh daily.

iii. Before anesthetizing animals with MS-222 researchers must saturate the solution with dissolved oxygen and buffer it to a neutral pH with sodium bicarbonate.

iv. Unused MS-222 solutions should be disposed of by using state-adopted procedures.

v. When using EN to induce anesthesia, NMFS recommends using low amperage direct current, as described by (Henyey et al. 2002)[8];

vi. Only non-stressed animals in excellent health may be anesthetized.

vii. To avoid injury to anesthetized sturgeon, researchers must use restraint in containers to prevent animals from jumping or falling out.

viii. When inducing anesthesia on sturgeon, researchers must observe fish at all times to establish the proper level of anesthesia has been reached.

ix. Upon encountering a sudden reflex reaction on an anesthetized fish during an invasive procedure, the researcher must stop the procedure and evaluate the level of anesthesia before proceeding.

x. Researchers must observe sturgeon for proper recovery from anesthesia prior to release.

f. Mortality or Serious Injury of Sturgeon:

i. Incidental mortality or serious harm of sturgeon is authorized in this permit (See Section III.A.2. and E2 of the permit)

ii. NMFS requests all incidental lethal takes or opportunistic (found) mortalities of sturgeon, are reported to Lynn Lankshear (Lynn.Lankshear@noaa.gov) (978) 282-8482). Specimens or body parts of dead sturgeon should be preserved—preferably iced or refrigerated—until sampling and disposal procedures are discussed with NMFS. Collected specimens should be documented as specified in Section E 10 of the permit.

C. Reporting Requirements

[8] Henyey, E., B. Kynard, and P. Zhuang. 2002. Use of electro-narcosis to immobilize juvenile lake and shortnose sturgeon for handling and the effects on their behavior. Journal of Applied Ichthyology 18: 502 - 504.

The Permit Holder must submit annual, final, incident, and genetic tissue sample reports, containing the information on listed and non-listed animals taken and in the format specified by the Permits Division. Written incident reports related to serious injury and mortality events, or to exceeding authorized takes, or the incidental harassment or interaction with a federally protected species, must be submitted to the Chief, Permits Division within 2 weeks of the incident. The incident report must include a complete description of events and identify the proposed steps taken to reduce the potential for additional research-related mortality or exceedance of authorized take.

A final report must be submitted to the Chief, Permits Division within 180 days after expiration of the permit, or, if the research concludes prior to permit expiration, within 180 days of completion of the research.

D. Notifications and Coordination

The Permit Holder must provide written notification of planned field work to the Assistant Regional Administrator for Protected Resources at the address listed below. Such notification must be made at least 2 weeks prior to initiation of any field trip/season and must include the locations of the intended field study and/or survey routes, estimated dates of research, and number and roles (for example: PI, CI, veterinarian, boat driver, safety diver, animal restrainer, Research Assistant "in training") of participants.

Northeast Regional Office, NMFS, Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930-2298; phone (978) 281-9300; fax (978) 281-9394. Email (*preferred*): NMFS.GAR.permit.notification@noaa.gov

To the maximum extent practical, the Permit Holder must coordinate permitted activities with activities of other Permit Holders conducting the same or similar activities on the same species, or affecting the same species, in the same locations, or at the same times of year to avoid unnecessary disturbance of animals. The appropriate Regional Office may be contacted at the address listed above for information about coordinating with other Permit Holders.

2.3 Action Area

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). The Action Area under these proposed activities would be the Delaware River and Estuary. The Delaware River is one of the major rivers of the eastern United States draining an area of 31,000 square kilometers (sq km). Beginning on the western slopes of the Catskill Mountains in eastern New York, the river consists of two branches: the West Branch, 145 km long, and the East Branch, 121 km long. The West Branch is the chief branch flowing southwest as far as Deposit, New York, and then turning southeast at the confluence at Hancock, New York rkm 452. From this point, the Delaware continues flowing southeasterly along the New York-Pennsylvania boundary as far as Port Jervis, New York. There, bordering Pennsylvania and New Jersey, it 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).

Sampling sites would be located in the tidally influenced portion of the lower Delaware River from rkm 119 to 148 in four separate locations (identified in Figure 1), however the Action Area could extend from rkm 90 to 165. A passive sonic telemetry array, maintained from the lower estuary (rkm 0) to near Trenton, New Jersey (rkm 216), would define the effective range of the study area where boats would also travel to download data from receivers.

Figure 1. The Action Area for research proposed to be conducted under Permit No. 19255.

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. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 C.F.R. 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. [9]

3.1 Overview of NMFS' 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.

[9] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

- 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. 19255 (Table 3). 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 3, along with their regulatory status.

Table 3. ESA-Listed species that may be affected by the NMFS Permits Division's issuance of permit number 19255 for scientific research on Atlantic and shortnose sturgeon in the Delaware River.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals			
Humpback Whale (*Megaptera novaeangliae*)	E – 35 FR 18319	-- --	55 FR 29646
North Atlantic Right Whale (*Eubalaena glacialis*)	E – 73 FR 12024	59 FR 28805	70 FR 32293
Sea Turtles			
Green Turtle (*Chelonia mydas*)	E – 43 FR 32800	63 FR 46693	63 FR 28359
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	75 FR 12496
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic DPS	E – 76 FR 58868	-- --	63 FR 28359
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	-- --	-- --
Atlantic Sturgeon, New York Bight DPS	E - 77 FR 5880	-- --	-- --
Atlantic Sturgeon, Chesapeake Bay DPS	E - 77 FR 5880	-- --	-- --
Atlantic Sturgeon, Carolina DPS	E – 77 FR 5914	-- --	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Atlantic Sturgeon, South Atlantic DPS	E – 77 FR 5914	-- --	-- --

4.1 ESA-listed 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: humpback whale (*Megaptera novaeangliae)*, North Atlantic right whale (*Balaena glacialis)*, green turtle *Chelonia mydas)*, Kemp's Ridley turtle (*Lepidochelys kempii)*, and loggerhead turtle (*Caretta caretta)*. Additionally, the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus)* Gulf of Maine DPS, Chesapeake Bay DPS, Carolina DPS, and South Atlantic DPS of will not be considered further in this opinion since only the New York Bight DPS inhabits the action area. The Delaware River Estuary does 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 river kilometer (rkm) 119 to 148, with a possible extension from rkm 90 to 165, and monitoring established acoustic array receivers by boat between rkm 0 to 216. Although sea turtles and listed marine mammals occur within the Action Area, the DNREC researchers have not yet encountered any in the described research area while sampling for Atlantic or shortnose sturgeon under previous permits. 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. Sea turtles and listed marine mammals may occur in Delaware Bay and the lower river, which encompasses the acoustic array monitoring area that would take place starting near rkm 0. However, a visual watch will be maintained during all boating activities. This is expected to minimize the likelihood of 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 within the NMFS Greater Atlantic Regional Fisheries Office in order to minimize interactions and/or impacts (see Section 2.2). These guidelines include: 1) maintaining a visual watch during all boating activities for protected species; 2) continual, complete, and thorough visual net checks; 3) net soak times between 30 min and 2 h, and 4) 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 30 min 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.

4.2 ESA-listed 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 4), 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 4. Populations defined in the Shortnose Sturgeon Recover Plan (NMFS 1998b).

Population Segments:	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 5). Both regional population and metapopulation structures may exist according to genetic analyses and dispersal and migration patterns (King et al. 2014; 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 1 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 D.O. 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 5. 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 1980)
		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)

Population/ Subpopulation	**Distribution**	**Datum**	**Estimate**	**Confidence Interval**	**Source**
		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		1-3,000		Bill Post, SCDNR, pers. comm 2003
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)
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 6). These captive individuals and populations have been developed from for educational purposes for research, enhancement, educational, and public display purposes.

Table 6. Examples of populations and individuals currently reared or held in captivity.

Permit No.	Location	Organization	Species	Exp. Date
14754	Dept. of Environmental Medicine, NYU School of Medicine	New York University School of Medicine	Shortnose Sturgeon (Egg/ Larvae)	2016-03-31
15596	North Carolina Aquarium	North Carolina Aquariums Division	Shortnose Sturgeon (Adult)	2016-01-15
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
17367	Warm Springs Regional Fisheries Center	U.S. Fish and Wildlife Service	Shortnose Sturgeon (Juvenile); Atlantic Sturgeon (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 (DO) also seems to play a role in temperature tolerance, with increased stress levels at higher temperatures with low DO versus the ability to withstand higher temperatures with elevated DO (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 1980; 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 (2 to 5 years for males and 4 to 5 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 1980). 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, 1 to 2 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 5 years post-maturation (Dadswell 1979), with spawning occurring approximately every 3 to 5 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 9 to 12 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 7 to 12 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). This species was first listed on the International Union for Conservation of Nature and Natural Resources Red List in 1986 where they are still listed as Vulnerable and facing a high risk of extinction. 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

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% 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 kilometers 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 1/3 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.

4.2.2 Atlantic Sturgeon

The Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* (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 (Acipenser brevirostrum), 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

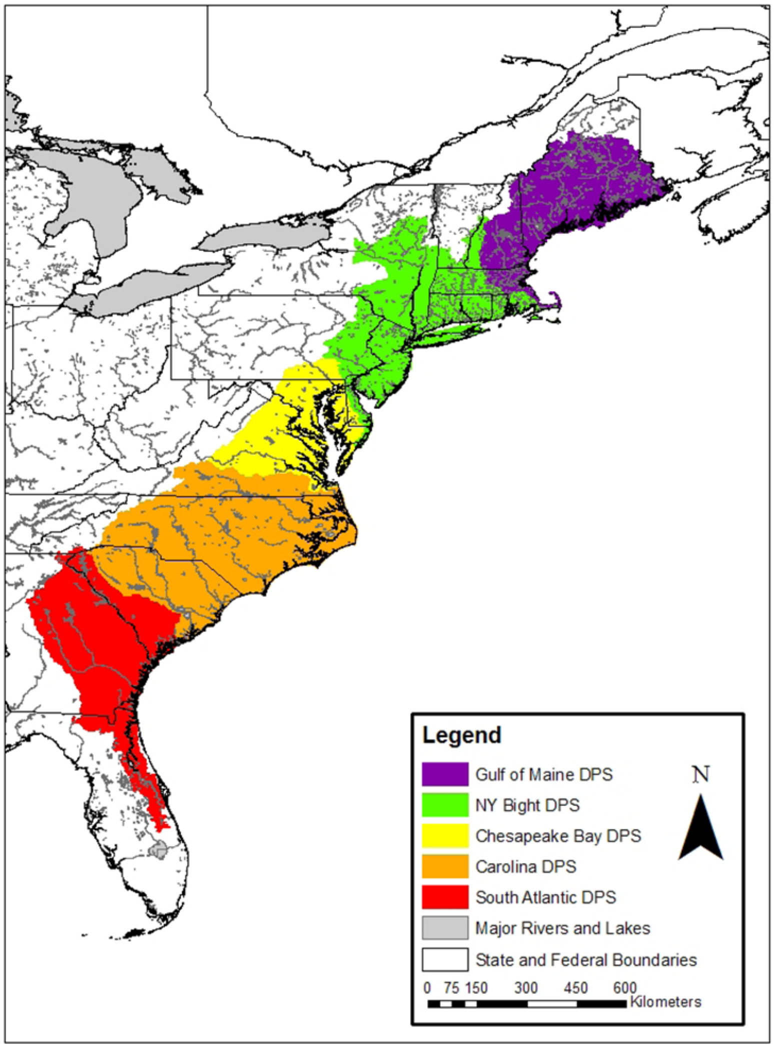

Figure 2. Range and boundaries of the five Atlantic sturgeon DPSs.

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 14 ft 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% of maximum lifetime egg production is achieved estimated to be 29 years, approximately 3 to 10 times longer than for other bony fish species examined (Boreman 1997). 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% 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 8 to 12 days, during which time the larvae move downstream to rearing grounds over a 6 to 12 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.

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 6th, 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% (295 mt) of its 1890 peak landings were reported. The landings continued to decline to about 5% of the peak until 1920 and have remained between 1-5% since then. During the 1950s, the remaining fishery switched to targeting sturgeon for flesh, rather than caviar. Between 1920 and 1998, the harvest level remained very low due to small remnant populations. The majority of these landings (75%) were dominated by the Delaware River fishery, which presumably supported the largest population along the Atlantic Coast (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 North East Fishery Science Center (NEFSC) developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (Kocik et al. 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance (Table 8). 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 United States Fish and Wildlife Service (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 7.

Table 7. Description of the ASPI model and NEAMAP survey based area estimate method.

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

Table 8. Modeled results of estimated population 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 9). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e. net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are 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% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most species. The 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% of the Atlantic sturgeon habitat).

Table 9. 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% 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. (2013) for catchabilities from 5 to 100%. 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% 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% catchability. The 50% catchability assumption seems to reasonably account for the robust, yet incomplete spatiotemporal 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 8). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the U. S. Fish and Wildlife Service (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% catchability rate (67,776 individuals; Table 8), 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% of this population abundance(calculated from Table 2 of Kocik et al. 2013) 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% subadult and adult individuals, including 10.6% in the Delaware River and 44% in the Hudson River populations (See Table 2 in Wirgin et al. 2015). Thus, this Opinion considers that the existing spawning population of adult Atlantic sturgeon in the Delaware and Hudson Rivers could consist of approximately 769 and 3,190 individuals, respectively. This is greater than the <300 spawning adults estimated by ASSRT (2007).

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.

4.2.2.6.1 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 (CWA). 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% 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% were from the New York Bight DPS.

At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. 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.

We are also not able to quantify any effects to habitat. 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.

4.2.2.7 Critical Habitat

The NMFS has not designated critical habitat for Atlantic sturgeon.

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions 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.

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.

Today, various wing dams currently exist on the Delaware, but no dams on the scale of requiring turbines and hydropower facilities. However, there are dams located among the Delaware River's tributaries. Located on the upper west branch of the Delaware River, the Cannonsville Reservoir exists as an impounding reservoir to supply 50% of the drinking water to New York, New York.

5.2 Dredging

Many rivers and estuaries 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 D.O. and high salinities upriver after channelization (Collins et al. 2001). Adult shortnose sturgeon can tolerate at least short periods of low D.O. 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 D.O. 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.

The Delaware River is an important commercial and recreational waterway that requires periodic dredging. For example, the bulk of dredging would be performed by hopper and hydraulic pipeline dredges with a bucket dredge used for rock removal 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. See biological opinions NER-2015-12624 and NER-2013-9804 for more information on the deepening of the Delaware River and maintenance of the 40 ft Delaware channel.

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 the Philadelphia to Trenton project include foraging, overwintering and nursery habitats. Since this time, no sturgeon mortalities have been observed.

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 (3 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 feet and some from 70 feet, 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 feet were less seriously injured by test blasting than those held at 35 feet 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.

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 DO, 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 (USN) and the U.S. Coast Guard (USCG), which maintain the largest federal vessel fleets, the EPA, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Army Corps of Engineers (USACE). NMFS has conducted formal consultations with the USCG, the USN, 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 USCG (NMFS 1995; 1996; 1998a) and the USN (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% 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. 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. Vessel interactions are thought to cause the death of several Atlantic sturgeon in the Delaware River each year.

5.6 Land Use Practices

In all, the Delaware River basin contains 13,539 square miles, draining parts of Pennsylvania (6,422 square miles or 50.3 percent of the basin's total land area); New Jersey (2,969 square miles, or 23.3%); New York (2,362 square miles, 18.5%); and Delaware (1,004 square miles, 7.9%) (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.

In the year 2000, the Delaware River basin population was estimated to consist of 7,758,675 people and it is expected to approach 9 million by 2030 (DRBC 2008). The Delaware River watershed is primarily divided between developed, agriculture, forest, wetlands and water, and “other” including mining uses (DRBC 2008). The major rivers draining into the Delaware are the Lehigh and Schuylkill Rivers. 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 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.

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 ITS, 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 5 shortnose sturgeon, 30 loggerhead sea turtles, 5 green sea turtles, and 5 Kemp's Ridleys. Since monitoring of 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 permit detailed in this Opinion, the two permits that the proposed permit would effectively renew (No. 14396) or replace (No. 16431), fish held in captivity, and import/export of fish parts, there are a total of 12 research permits (Table 10) authorizing the sampling (take) of shortnose and New York Bight DPS Atlantic sturgeon on the east coast of the United States. Of these permits, currently 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. The activities authorized under these permits are presented in Table 10 (NMFS 2015).

Table 10. Existing shortnose and Atlantic sturgeon research permits authorized for wild populations. Note: juv = juvenile and all egg/larvae takes are considered intentional mortalities.

Permit No.	Location	Authorized Take	Research Activity
14604 Expires 4/19/2016 Shortnose sturgeon	Delaware River and Estuary	896 adult/juv 1 adult/juv (unintentional mortality) 74 adult 30 juv 500 egg/larvae	Anesthetize; Instrument, internal (e.g., VHF, sonic); Intentional (directed) mortality; Laparoscopy ; Mark, Floy T-bar; Mark, PIT tag; Measure; Other; Salvage (carcass, tissue, parts); Sample, blood ; Sample, fin clip; Sample, gonadal tissue biopsy; Weigh
15614 Expires 5/23/2016 Shortnose sturgeon	Connecticut River	500 adult/juv	Instrument, internal (e.g., VHF, sonic); Lavage; Mark, PIT tag; Measure; Sample, fin clip; Sample, fin ray clip; Weigh
15677 Expires 5/31/16 Shortnose sturgeon	S. Carolina Rivers	100 egg/larvae 134 adult/juv 20 juv	Anesthetize; Collect eggs; Collect, sperm; Instrument, internal (e.g., VHF, sonic); Intentional (directed) mortality; Laparoscopy ; Mark, dart; Mark, PIT tag; Measure; Photograph/Video; Sample, blood ; Sample, gonadal tissue biopsy; Sample, other tissue ; Weigh
16306 Expires 5/21/17 Shortnose sturgeon	Penobscot River	335 adult 25 juv 50 egg/larvae	Anesthetize; Boroscope; Instrument, external (e.g., VHF, satellite); Instrument, internal (e.g., VHF, sonic); Intentional (directed) mortality; Lavage; Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph/Video; Sample, blood ; Sample, fin clip; Sample, fin ray clip; Sample, other tissue ; Weigh
	Kennebec River	568 adult 25 juv 50 egg/larvae	
	Saco River	132 adult 5 juv 10 larvae	
	Atlantic Ocean, Maine	300 adult/juv	
	Atlantic Ocean, Massachusetts	290 adult/juv 115 juv 100 egg/larvae	
16323 Expires 4/5/2017 NYB DPS Atlantic sturgeon	Long Island Sound	275 adult/juv	Anesthetize; Instrument, internal (e.g., VHF, sonic); Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph/Video; Sample, fin clip; Weigh
16422 Expires 4/5/2017 NYB DPS Atlantic sturgeon	In the marine and estuarine waters of Connecticut, New York, New Jersey, and Delaware including the Atlantic Ocean and Long Island Sound	525 adult/juv	Anesthetize; Instrument, external (e.g., VHF, satellite); Instrument, internal (e.g., VHF, sonic); Lavage; Mark, dart; Mark, PIT tag; Measure; Other; Photograph/Video; Sample, blood ; Sample, fin clip; Sample, fin ray clip; Sample, other tissue ; Weigh

Permit No.	Location	Authorized Take	Research Activity
16436 Expires 4/5/2017 NYB DPS Atlantic (AS) and shortnose sturgeon (SS)	Hudson River, Haverstraw Bay	AS 603 juv SS 200 adult/juv	Anesthetize; Instrument, internal (e.g., VHF, sonic); Collect eggs; Laparoscopy ; Lavage; Mark, dart; Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph/Video; Sample, blood ; Sample, fin clip; Sample, gonadal tissue biopsy; Treatment, prophylactic; Weigh
	Atlantic Ocean, Hudson River, New York	AS 370 adult AS 1050 juv	
	Atlantic Ocean, Hudson River (river wide), New York	SS 2,363 adult/juv AS 30 adult/juv	
	Hudson River Estuary	SA 3 juv SS 3 adult/juv	Unintentional mortality
16438 Expires 4/5/2017 NYB DPS Atlantic sturgeon	Delaware River and Bay	384 juv 1 juv (unintentional mortality) 50 egg/larvae	Anesthetize; Instrument, internal (e.g., VHF, sonic); Intentional (directed) mortality; Laparoscopy ; Lavage; Mark, Floy T-bar; Mark, PIT tag; Measure; Photograph/Video; Sample, blood ; Sample, fin clip; Unintentional mortality; Weigh
16482 Expires 4/5/2017 NYB DPS Atlantic (AS) and shortnose sturgeon (SS)	Savannah River	AS 100 adult AS 1000 juv AS 50 egg/larvae SS 270 adult/juv	Anesthetize; Instrument, internal (e.g.,VHF,sonic); Laparoscopy ; Mark,Floy T-bar; Mark,PIT tag; Measure; Photograph/Video;); Intentional (directed) mortality; Sample,blood ; Sample,fin clip; Sample,gonadal tissue biopsy; Weigh
	Ogeechee River	AS 80 adult AS 100 juv AS 50 egg/larvae SS 10 adult SS 100 adult/juv SS 50 egg/larvae	
	Altamaha River	AS 120 adult AS 1,950 juv AS 50 egg/larvae AS 70 adult/juv SS 10 adult SS 340 adult/juv SS 20 egg/larvae	
	Satilla River	AS 30 adult AS 60 adult/juv AS 50 egg/larvae AS 40 juv SS 10 adult SS 50 egg/larvae SS 20 adult/juv	
	St Marys River	AS 30 adult AS 100 juv AS 50 egg/larvae SS 10 adult SS 50 egg/larvae SS 20 adult/juv	
	St. Johns and Nassau River, FL	AS 30 adult/juv AS 50 egg/larvae SS 30 adult/juv SS 50 egg/larvae	
	Atlantic Ocean, Georgia Rivers, Estuaries, and coastal	AS 6 adult/juv SS 2 adult/juv	Unintentional mortality

Permit No.	Location	Authorized Take	Research Activity
	marine areas		
16507 Expires 4/5/2017 NYB DPS Atlantic (AS) and shortnose sturgeon (SS)	Delaware River Estuary	AS 350 egg AS 100 juv SS 100 juv	Anesthetize; Instrument,external (e.g.,VHF,satellite); Instrument,internal (e.g.,VHF,sonic); Mark,Floy T-bar; Mark,PIT tag; Measure; Photograph/Video; Sample,fin clip; Sample,gonadal tissue biopsy; Weigh
	Atlantic Ocean, Delaware	AS 410 adult/juv	
16549 Expires 4/8/2018 Shortnose sturgeon	Upper Connecticut River	100 adult 100 juv 150 egg/larvae	Anesthetize; Boroscope; Captive, field studies; Instrument, external (e.g., VHF, satellite); Instrument, internal/external ; Intentional (directed) mortality; Mark, PIT tag; Measure; Salvage (carcass, tissue, parts); Sample, fin clip; Transport; Treatment, prophylactic; Weigh
	Lower Connecticut River	100 adult	Anesthetize; Boroscope; Captive, breed; Captive, lab experiments; Collect eggs; Collect, sperm; Instrument, external (e.g., VHF, satellite); Instrument, internal (e.g., VHF, sonic); Mark, PIT tag; Measure; Sample, blood ; Sample, fin clip; Transport; Treatment, prophylactic; Weigh
	Connecticut River	3	Unintentional mortality
17095 Expires 8/28/2017 NYB DPS Atlantic (AS) and shortnose sturgeon (SS)	Hudson River	AS 200 adult/juv AS 40 egg/larvae SS 82 adult/juv SS 40 egg/larvae	Mark,dart; Mark,PIT tag; Measure; Sample,other tissue ; Weigh

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% 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 sturgeon. 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% were bycatch mortality and another 20% 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).

Fishing for weakfish occurs in Delaware Bay, 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% from 1989 to 2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of 0.02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007).

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% 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% to 10%, 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%). 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 DO 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

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

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the

Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose and Atlantic sturgeon are tolerant to water temperatures up to approximately 28°C; these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

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

5.10.3 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.

(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% 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.

5.11 Conservation

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. Members include the four basin state governors and the Division Engineer, North Atlantic Division, U.S. Army Corps of Engineers, who serves as the federal representative. 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. The upper portion flows between Hancock and Sparrow Bush, New York, along the Pennsylvania border and stretches for 73 miles. The middle portion flows for 35 miles through the Delaware Water Gap National Recreation Area and cuts an "S" curve through Kittatinny Ridge. The lower portion contains several segments of the Delaware River and its tributaries: 1) from river mile 193.8 to the northern border of the city of Easton, Pennsylvania; 2) from just south of the Gilbert Generating Station to just north of the Point Pleasant Pumping Station; 3) from just south of the Point Pleasant Pumping Station to a point 1,000 feet north of the Route 202 Bridge; 4) from 1,750 feet south of the Route 202 Bridge to the southern boundary of the town of New Hope, Pennsylvania, to the town of Washington Crossing, Pennsylvania; 5) all of Tinicum Creek; 6) Tohickon Creek from the Lake Nockamixon Dam to the Delaware River; and 7) Paunacussing Creek in Solebury Township.

Section 303(d) of the Federal Clean Water Act (CWA) 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 of Delaware, Pennsylvania, New Jersey, and New York are responsible for implementing TMDLs for the Delaware River.

All of the states along the Delaware River – Pennsylvania, New Jersey, New York, and Delaware – each have State Departments of Conservation managing programs which impact the Delaware River 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 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 Atlantic sturgeon are considered endangered and undergoing declines in population abundance. 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 and Critical Habitat

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 number 19255 would expose ESA-listed Atlantic and shortnose sturgeon to gill net capture, handling, genetic tissue sampling, tagging, and anesthesia. Additionally, Atlantic sturgeon would be exposed to gastric lavage and fin ray clips. 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 net capture; 2) handling for procedures and measurements; 3) genetic tissue sampling; 4) PIT tagging; 5) T-bar tagging; 6) anesthesia; 7) internal acoustic tagging; 8) gastric lavaging (Atlantic sturgeon); 9) fin ray clipping (Atlantic sturgeon); 10) recaptures; and 11) incidental mortality. Activities will occur in the Delaware River and Estuary 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.

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 2.1.

6.3.1 Gill 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). 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 11 below. Mortality rates due to the netting activities ranged from 0 to 1.22%. Of the total 5,911 shortnose sturgeon captured by gill nets or trammel nets, only 23 died, yielding an average incidental mortality rate of 0.39%. All of the mortalities associated with these permits were due to high water temperature and low dissolved oxygen (DO) concentrations. Moser and Ross (1995) reported gill net mortalities approached 25% when water temperatures exceeded 28ºC, even though soak times were often less than 4 hours. Under Permit Number 1247, between 4 and 7% of the shortnose sturgeon captured died in nets prior to 1999, whereas between 1999 and 2005, none of the more than 600 shortnose sturgeon gill netted died as a result of their capture. Also, in five years, under Permit Number 1189, none of the sturgeon captured died. Under Permit Number 1174, all seven of the reported shortnose sturgeon mortalities occurred during one sampling event.

Table 11. 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 DO, increased temperature, and increased salinity (summarized in Kahn and Mohead 2010). While gill 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 gill 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 6.3.10. 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 sturgeon populations. By extension, capture is not likely to reduce the viability of the New York Bight 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 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 D.O. 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 Atlantic or shortnose sturgeon populations. By extension, handling is not likely to reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.3 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 sturgeon populations. By extension, genetic tissue sampling is not likely to reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.4 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% of the yearling Chinook salmon (*Oncorhynchus tshawytscha*) and 0.3% of the yearling steelhead (*O. mykiss*) studied by Muir et al. (2001) died from PIT tag insertions after 24 hours. In 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% 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% of age-0 Atlantic salmon (*Salmo salar*) died within 12 hours of having PIT tags surgically implanted posterior to their pectoral fins, but nine months later, 5.7% of the 3,000 tagged fish had died. At the conclusion of a month long study by Dare (2003), 325 out of 144,450 tagged juvenile spring chinook salmon died, but only 42 died in the first 24 hours.

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 the Delaware River Atlantic and shortnose sturgeon populations. By extension, PIT tagging is not likely to reduce the viability of the New York Bight DPS of Atlantic sturgeon and shortnose sturgeon as listed under the ESA.

6.3.5 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 10-years after tagging (although no data are available to evaluate any effects on growth rate). Studies on other species suggest that the long-term effect of injecting anchor tags into the muscle may be variable. Researchers have observed reduced growth rates in lemon sharks and northern pike from tagging, whereas studies of largemouth bass did not 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 the Delaware River Atlantic and shortnose sturgeon populations. By extension, T-bar tagging is not likely to reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.6 Anesthesia

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

6.3.6.1 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 sturgeon or reduce the viability of the New York Bight 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.

6.3.6.2 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 3 to5 minutes and 5 to 7 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% 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 5 or 30 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 6 weeks, observing no adverse effects in that time. Furthermore, researchers under NMFS permit number 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 sturgeon or reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.7 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% survival and retention over their study period. DeVries (2006) reported movements of 8 male and 4 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 4 months. Periodic checks for an additional 2 months also showed no movement. Although there were no known mortalities directly attributable to the implantation procedure; the status of the 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 two 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% of the animal. The researchers found that when the weight of the transmitter reached 4%, 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% 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 2-10% of their body weight (i.e., radio transmitters) versus fish with tags representing <1% of their body weight (i.e., PIT tags). Kahn and Mohead (2010) recommend not exceeding a tag to body weight ratio of 1.25% in water and 2% 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% 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 Atlantic or shortnose sturgeon. Therefore, this activity is not likely to reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.8 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 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 Delaware River or reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.9 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 removing the entire ray (as opposed to a small section as is being proposed in permit 19255) from the base, 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 Delaware River or reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.10 Recaptures

The researchers do not anticipate a high number of recaptures of either Atlantic or shortnose sturgeon based on the numbers of recaptures during previous sturgeon research in Permits No. 16431 and 14396. However, sampling efforts are expected to increase, thus additional sturgeon recaptures may be observed towards the end of the year. We anticipate these 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 Atlantic or shortnose sturgeon. Therefore, this activity is not likely to reduce the viability of the New York Bight DPS of Atlantic sturgeon or shortnose sturgeon as listed under the ESA.

6.3.11 Incidental mortality

Permit number 19255 would authorize research related mortality to Atlantic and shortnose 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). The researcher has maintained a record of verifiable mortality in previous authorized research in the same Action Area and he anticipates at least one shortnose and one Atlantic sturgeon mortality from his proposed research annually, but not to exceed two shortnose sturgeon over the five-year term and one Atlantic sturgeon over the five-year term. 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 12 total other NMFS-issued permits allowing take of shortnose and New York Bight DPS Atlantic sturgeon (not including Permit No. 14396 and 16431); five shortnose sturgeon permits, four New York Bight DPS Atlantic sturgeon permits, and three combined shortnose and Atlantic sturgeon permits on the eastern seaboard. Of these, five are NMFS-issued permits allowing incidental mortality of either or both species (Table 10).

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.

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 one shortnose sturgeon mortality 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%. It's 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 shortnose sturgeon. Therefore, it is much more likely that any unintentional mortality would be of juvenile fish, which are more abundant than spawning adults. For these reasons, the anticipated impact of two shortnose sturgeon mortalities on the Delaware River 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 per year and two incidental mortalities throughout the life of the permit would not appreciably reduce the likelihood of the survival and recovery of the Delaware River shortnose sturgeon population. Therefore, it is unlikely to reduce the likelihood of the survival and recovery of the shortnose sturgeon population as listed under the ESA.

The New York Bight DPS of Atlantic sturgeon is known to spawn in two rivers, the Hudson and Delaware (ASSRT 2007). Using our calculations from the research of Kocik et al. (2013) and Wirgin et al. (2015), we estimate the existing spawning population of adult New York Bight DPS Atlantic sturgeon in the Hudson and Delaware Rivers could consist of approximately 3,190 and 769 individuals, respectively. This is greater than the 300 spawning adults estimated by the Atlantic sturgeon status review team (ASSRT 2007) and 870 spawning adults per year by Kahnle et al. (2007). Based on the latest estimate of the number of spawners in the Hudson River and the Delaware River, we can estimate that 0.025% of the New York DPS of Atlantic sturgeon will be killed by the proposed action. It's 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. We do not have an estimate of the absolute abundance of juvenile Atlantic sturgeon in the New York Bight 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 than adults. Therefore, the anticipated impact of one Atlantic sturgeon mortality on the Delaware River 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 of Atlantic sturgeon over the life of the five year permit is unlikely to reduce the likelihood of the survival and recovery of the Delaware River population. Therefore, it is unlikely to reduce the likelihood of the survival and recovery of the New York Bight DPS of Atlantic sturgeon 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 permit, listed sturgeon would be exposed to the following potential stressors: gill net capture, handling for procedures and measurement, genetic tissue sampling, PIT tagging, T-bar tagging, anesthesia, internal acoustic tagging, gastric lavage, and fin ray clipping. As described in Section 6.3, with the exception of rare instances of incidental mortality, 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 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 of Atlantic sturgeon or shortnose sturgeon as listed under the ESA. The proposed permit 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. However, as described in Section 6.3.10, 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 New York Bight DPS of Atlantic sturgeon or shortnose 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. 19255 to the DNREC for research on the New York Bight DPS of Atlantic sturgeon and shortnose 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 the New York Bight DPS of Atlantic sturgeon and shortnose 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 number 19255 to the Delaware Department of Natural Resources and Environmental Control, Fish and Wildlife Division for research on Atlantic and shortnose sturgeon in the Delaware River and estuary is unlikely to lead to any fitness consequences to any individuals, with the exception of rare instances of incidental mortality. Additionally, we concluded that 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, it is NMFS' opinion that the issuance of permit number 19255 is likely to adversely affect, but is not likely to jeopardize the continued existence of the New York DPS of Atlantic sturgeon or shortnose sturgeon.

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 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 number 19255 to the Delaware Department of Natural Resources and Environmental Control, Fish and Wildlife Division for research on Atlantic and shortnose sturgeon in the Delaware River and estuary. 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 contact the ESA Interagency Cooperation Division, Office of Protected Resources immediately.

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