Appendix F: Ecology

F-14 NMFS Biological Opinion on Pile Installation Demonstration Project

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

MAR - 7 2012

Mr. Jonathan McDade
Division Administrator, New York Division
U.S. Federal Highway Administration
Leo W. O'Brien Federal Building, Room 719
11A Clinton Avenue
Albany, New York 12207

RE: Transmittal of Biological Opinion-- Tappan Zee Bridge Pile Installation Demonstration Project (PIDP)

Dear Mr. McDade,

Please find enclosed a copy of the Biological Opinion (Opinion) on the effects of the proposed Tappan Zee Bridge PIDP. In this Opinion, we conclude that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence of endangered shortnose sturgeon, the threatened Gulf of Maine Distinct Population Segment (DPS) of Atlantic sturgeon, the endangered New York Bight DPS of Atlantic sturgeon or the endangered Chesapeake Bay DPS of Atlantic sturgeon.

Our Opinion includes an Incidental Take Statement (ITS). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements, including any state endangered species laws or regulations, except for the prohibition against taking in ESA Section 9. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

This ITS exempts the following take:

- A total of no more than 19 shortnose sturgeon injured during the installation of the 7 test piles to be driven by an impact hammer; and,
- A total of no more than 19 Atlantic sturgeon injured during the installation of the 7 test piles to be driven by an impact hammer. Based on mixed stock analyses, we anticipate that no more than 1 of the Atlantic sturgeon will be GOM DPS origin and no more than 1 will be Chesapeake Bay DPS origin. The remaining 17 Atlantic sturgeon will be

New York Bight DPS origin.

The ITS specifies reasonable and prudent measures necessary to minimize and monitor take of shortnose and Atlantic sturgeon. The measures described in the ITS are non-discretionary, and must be undertaken by FHWA so that they become binding conditions for the exemption in section 7(o)(2) to apply. FHWA has a continuing duty to regulate the activity covered by this Incidental Take Statement. If FHWA (1) fails to assume and implement the terms and conditions or (2) fails to require the project sponsor or their contractors to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to permits and/or contracts as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, FHWA or the project sponsor must report the progress of the action and its impact on the species to the NMFS as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

This Opinion concludes formal consultation for the proposed action as currently defined. Reinitiation of this consultation is required if: (1) the amount or extent of taking specified in the ITS is exceeded; (2) new information reveals effects of these actions that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) project activities are subsequently modified in a manner that causes an effect to the listed species that was not considered in this Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

Should you have any questions regarding this Opinion please contact Julie Crocker of my staff at (978)282-8480. I look forward to continuing to work with you and your staff during future Section 7 consultations.

Sincerely,

Daniel S. Morris
Acting Regional Administrator

Enclosure

EC: Crocker, F/NER3
Rusanowsky, F/NER4
Toni, FHWA
Tomer, ACOE
Wilson, NYDEC

File Code: Sec 7 FHWA Tappan Zee PIDP
PCTS: F/NER/2011/05769

ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Agency:	Federal Highway Administration, New York Division Army Corps of Engineers, New York District
Activity:	**Tappan Zee Pile Installation Demonstration Project** **F/NER/2011/05769**
Conducted by:	NOAA's National Marine Fisheries Service Northeast Regional Office
Date Issued:	MAR - 7 2012
Approved by:	

INTRODUCTION

This constitutes NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Opinion) issued in accordance with section 7 of the Endangered Species Act of 1973, as amended, on the effects of the proposed Tappan Zee Bridge Pile Installation Demonstration Project. The U.S. Federal Highway Administration (FHWA) is funding the PIDP. The U.S. Army Corps of Engineers (ACOE) is authorizing the project under Section 10 of the Rivers and Harbors Act.

We are basing this Opinion on information provided in a Biological Assessment (BA) dated November 21, 2011, a revised BA dated January 9, 2012, and other sources of information. A complete administrative record of this consultation will be kept on file at the NMFS Northeast Regional Office, Gloucester, Massachusetts.

BACKGROUND AND CONSULTATION HISTORY

NMFS began coordination with FHWA, the New York Department of Transportation (DOT), the New York State Thruway Authority (NYSTA), and their project team in 2006 regarding the potential replacement of the Tappan Zee Bridge. At a meeting on October 14, 2011, FHWA presented information on the proposed PIDP. FHWA sent a BA to NMFS on November 22, 2011. We requested more information from FHWA in a letter dated December 14, 2011. We received a revised BA on January 9, 2012. We discussed the project at a December 14, 2011 meeting with the project team. We transmitted a draft Opinion to FHWA, the ACOE and the project team on February 15, 2012. We received comments from FHWA on February 28, 2012 and discussed these comments on a February 28, 2012 conference call. The ACOE indicated that they would not be providing any comments on the draft Opinion. All comments received have been addressed as appropriate.

DESCRIPTION OF THE PROPOSED ACTION

FHWA is funding the PIDP and the ACOE, New York Division is permitting the project. NY

DOT, the NYSTA and their contractors, will carry out the project. The FHWA is the lead Federal agency for the project for purposes of this ESA consultation and coordination under the National Environmental Policy Act.

Summary of Scope of PIDP

The proposed PIDP includes the installation and testing of seven piles clustered at four locations across the Hudson River (Figure 1), immediately to the north of the existing TZB. Additionally, approximately 75 ancillary piles (1-2' diameter) will be installed.

The four locations have been selected as representing four distinct geological stratigraphies encountered along the approximately three-mile span of the crossing alignment. Specifically:

- Two of the pile test locations are on deep river bed sediments, one of which (denoted PLT-1 in Figure 1) is in an area of relatively soft sediment, and the other (PLT-2) is in an area of relatively stronger sediment of glacial origin.

- Two of the pile test locations are located where relatively thinner sediment overlies two different types of rock (sandstone and gneiss at PLT-3 and PLT-4, respectively).

At PLT-1 and PLT-2 (in the areas of deep sediment), the piles will be founded within the river bed sediments. At PLT-3 and PLT-4, where the bedrock is suitably shallow, the piles will be founded either on the rock (that is, the pile ends will bear onto the rock head surface) or socketed into the upper part of the rock stratum (typically, the sockets will extend approximately 20 ft into the rock).

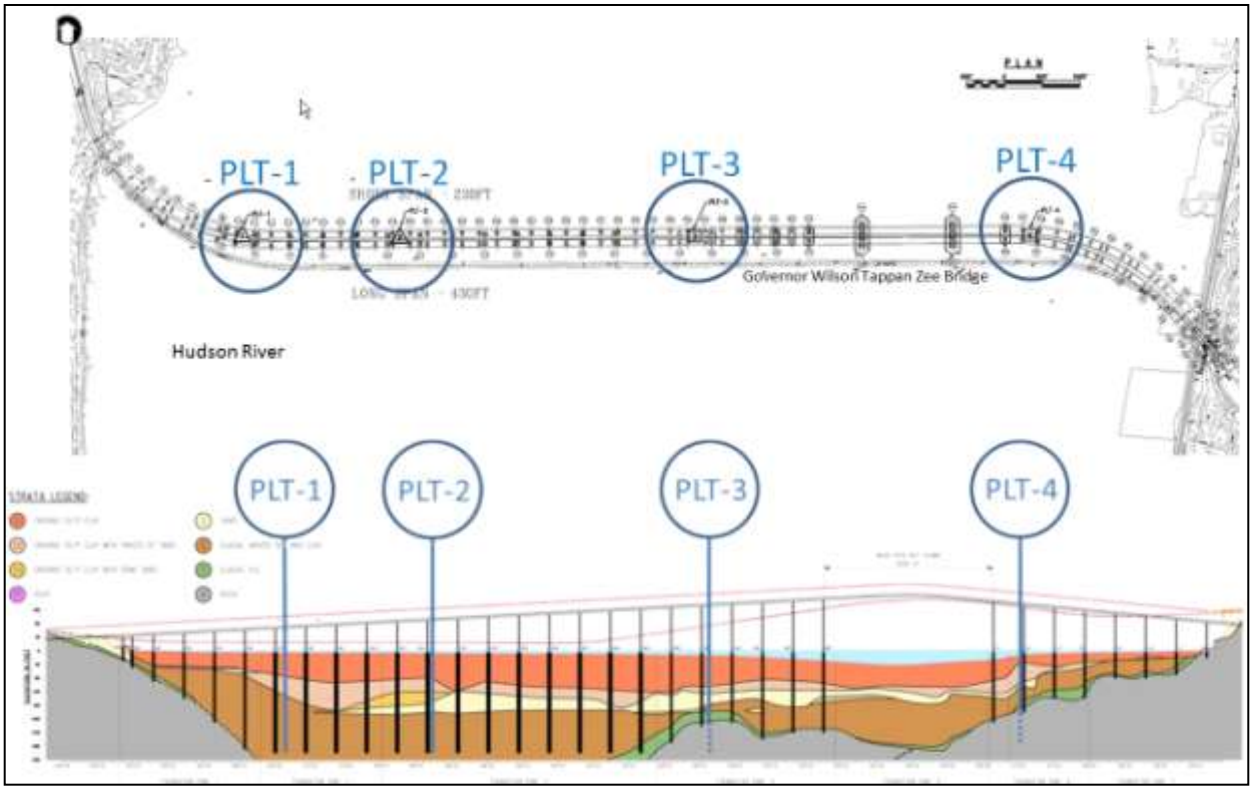

Figure 1 Proposed Location of Four Pile Test Zones in Hudson River (Plan and Section Views). *Figure provided by FHWA in 2012 BA.*

Two piles each will be installed at PLT-1, PLT-2 and PLT-3 and one pile will be installed at PLT-4. Table 1 details the pile types and sizes. Table 3 details the noise attenuation systems to be tested. No more than 1 test pile will be installed per day. Each pile will involve 1-5 hours of driving. Based on the available schedule, piles are expected to be installed on 7 days between April 26, 2012 and May 23, 2012. Pile driving will occur for less than 5 hours for each of the 7 test piles. After approximately 7 days, each pile will be "redriven." This redriving involves using a "Pile Driving Analyzer" which is an electronic system used to measure hammer and drive system performance during approximately 10 pile driving blows. The redriving is expected to take less than 1 minute for each pile. All redriving will be completed by June 9, 2012.

The test piles will be installed by effective pile driving. Specifically, the following pile installation methods and pile types will be used:

- Effective driving of open-ended hollow steel pipe piles (in sediment).
- Effective driving of open-ended hollow steel pipe piles, driven to bear onto rock head.
- Effective driving of open-ended hollow steel pipe piles, driven to bear onto rock head, followed by rotary drilling into the top of the rock to form a rock socket, with the bottom of the shaft being formed as a cast-in-place reinforced concrete.

Prior to any "full energy" pile driving for the test piles, a ramp-up or "soft start" method will be used. This involves a series of taps at 25-40% of the pile driver's energy that is designed to serve as a "warning" to fish in the project area. This method is designed to cause fish to leave the area prior to full energy pile driving.

The approximately 75 ancillary piles will be installed using a vibratory method. Installation of the ancillary piles is expected to be completed in less than 3 days at each location.

Table 1. Summary of Types and Dimensions of Proposed Test Piles and Ancillary Piles for PIDP (*Table from the 2012 BA*)

Pile reference	Method of installation	Pile type	Pile diameter (ft)	Pile wall thickness (inches)	Pile length (ft)	Depth of penetration below river bed (ft)	Estimated Actual Pile Driving Time** (hours)
Area PLT-1 (in sediments)							
PLT1-1	driven	open-ended, hollow tube	4	1	300	293	4.6
PLT1-2	driven	open-ended, hollow tube	4	1	300	293	4.6
Area PLT-2 (in sediments including glacial deposits)							
PLT2-1	driven	open-ended, hollow tube	4	1.25	300	278	4.6
PLT2-2	driven	open-ended, hollow tube	4	1.25	300	278	4.6
Area PLT-3 (on sandstone rock)							
PLT3-1	driven to rock head	open-ended, hollow tube	4	1.25	236	194	1
PLT3-2	casing driven to rock; shaft socketed into rock	permanent casing, cast-in-place concrete	8	2	236	194	1.85
Area PLT-4 (on gneiss rock)							
PLT4-4	driven to rock	open-ended, hollow tube	10	2	204	156	1.6
Ancillary support piles (75 total piles)							
All 4 test locations	Vibrated In	open ended pipe piles	1 to 2	0.5 to 0.75	150	150	94 (total)

**The test piles will be installed in two sections. FHWA has indicated that the first section is likely to be installed with a vibratory hammer, but it is possible if conditions are not as expected, that an impact hammer may be needed during the installation of the first half of the pile. These time estimates assume the worst case, that an impact hammer is used for the entire installation of the first and second portions of each test pile.

At each of three test areas (PLT-1 to 3), the proposed load testing regime for the test piles is as follows:

- One pile to be statically load tested, using a load frame to apply static load to the pile head;
- One pile to be pseudo-statically tested, using a statnamic load testing device; and,
- A pair of 4 ft diameter piles will be load tested laterally (by jacking the piles apart).

The single 10 ft diameter pile, at PLT-4, will not be load tested. The reason for this is that, in general when load testing a pile, the goal should be to take it to engineering ultimate failure (defined as a certain amount of settlement). The ultimate failure load of the 10 ft diameter pile is likely to be too high to be reached using the proposed loading systems. Instead, dynamic pile driving analysis of the 10 ft pile (i.e., Pile Driving Analyzer (PDA) testing, using accelerometers and strain gages attached to the pile) will be used during driving to gain information about the drivability of a casing/pile of this dimension and inferring the load-bearing capacity. PDA testing will also be used during the driving of all the test piles and casings installed by effective methods.

Ancillary support piles will be used to support the load frame for the static load testing, the statnamic loading device, and the transverse load system for the lateral load tests. It is anticipated that the PIDP contractor will use approximately 25 ancillary piles at each of the three testing locations, totaling approximately 75 ancillary piles for the PIDP. FHWA anticipates that the ancillary piles will be no greater than 2 ft in diameter and 150 ft long. These piles will be vibrated into the sediment. It is anticipated that installation of the ancillary piles will take less than three days at each location.

None of the piles to be installed during the PIDP will be incorporated in the permanent foundations of a future crossing. The proposed locations of all the PIDP piles are offset from the anticipated alignment of TZHRC.

Summary of Site Work for PIDP

Pile driving will be accomplished with a pile driving hammer suspended from a crane operating from a moored barge. The specific details of the installation equipment will depend on the range of equipment available to the PIDP contractor. The piles would be installed in two sub-sections, a lower section typically of 150 ft length and an upper section of up to 150 ft length typically. The two sections would be connected by welding. A barge-mounted 300 ton crawler crane would be used to lift 150 ft long sub-sections into place and to support the hammer during pile driving. A high-efficiency hydraulic effect hammer, which provides on the order of 200 to 400 kip-ft of energy during driving, would be used to progress the piles to their final depths.

For the rotary drilling works, for rock coring to form rock sockets, the installation equipment will be mounted on a barge served by the barge-mounted crane.

The on-site crew will work from two material barges, one crane barge, and one tugboat. Low-draft vessels will be used for personnel movements between the workboats. These vessels would have drafts less than 5 ft. The water depths at PLT-1 is 9.2 ft, at PLT-2 is 11.4 ft, at PLT-3 is 17.7 ft and at PLT-4 is 16.6 ft; thus, there will always be at least 4 feet of clearance between the vessels and the river bottom. Table 2 summarizes the anticipated type and frequency of vessel movements. FHWA anticipates that at least two test zones (that is, any two of PLT-1 to 4) will have work going on simultaneously and there will be boat traffic between these areas of activity. FHWA expects that all vessels will remain on-site for the duration of the PIDP. Vessels are likely to be moored against ancillary piles used for the test support system, except during loading test periods, when anchors will be used.

Table 2. Anticipated Vessel Movements for PIDP

Vessel Type	Number	Movement Description
Material Barges	2	Tugs will tow material barges to the test pile location from the Contractor's storage facility. Once in position at a test pile, it will be likely stay at the test pile location until it has been completely unloaded. Smaller material barges may move more frequently.
Crane Barge	1	Crane barges will be moved into position at the test pile location and will generally be stationary until the test piles and ancillary support piles have been driven and the load test frame is installed. Within a given test zone (PLT-1 to 4), there is likely to be some local movement around the individual test pile locations to drive all the piles in that area.
Tugboats	1	Tugboats, with high-propellers, will move material barges around the test pile locations frequently during the day.
Light vessels	3	Light craft traffic will move personnel and small equipment back and forth from the contractor’s staging area and the in-river work areas.

Hydroacoustic and Sediment Mitigation Systems for the PIDP

The PIDP contractor will be required to utilize a turbidity curtain (i.e., silt curtain) around each work area in order to limit the potential for downstream transport of any fine sediment that may go into suspension within the water column around the piling area if they are determined not to impede the acoustic monitoring analysis.

The proposed PIDP includes site-specific testing of a range of hydroacoustic mitigation systems that could be used in any future construction work for a new bridge (see Table 3). The project team will test bubble curtains (both single ring and multiple ring options including the Gunderboom technology), isolation casings (a large pile in which another pile is driven), and combined casing and bubble systems. The purpose of the sound attenuation system trials will be to provide site-specific information about the performance of the systems in order to:

- Assess practical aspects of the site-specific implementation of these system, in the context of the water currents, water depths, pile driving conditions, etc., that are specific to the area of interest;
- Assess hydroacoustic monitoring locations for use in developing any future construction monitoring program; and,
- Provide information to help establish construction schedules and cost estimates for piling works, by providing site-specific information to any future construction contractor.

Table 3. Noise Attenuation System Installation and Operation Schedule (from FHWA 2012 BA)

Pile ID	Pile Diameter (ft)	Noise Attenuation System Type	Pile Seg-ment	Cycles	Compressed Air Flow Rate (scfm/lf)		
					Cycle Segment 1	Cycle Segment 2	Cycle Segment 3
PLT-1-1	4	Unconfined Single-Tier Air Bubble Curtain System	1	2	Off	22	35
			2	2	Off	22	35
PLT-1-2	4	Hard Bubble System	1	N/A	N/A	N/A	N/A
			2	N/A	N/A	N/A	N/A
PLT-2-1	4	Unconfined Multi-Tier Air Bubble Curtain System	1	2	Off	22	35
			2	2	Off	22	35
PLT-2-2	4	Isolation Casing and Bubble System	1	2	Off	22	35
			2	2	Off	22	35
PLT-3-1	4	Unconfined Multi-Tier Air Bubble Curtain System	1	2	Off	22	35
			2	2	Off	22	35
PLT-3-2	8	Two-Stage Confined Bubble Curtain System	1	2	Off	22	35
			2	2	Off	22	35
PLT-4-1	10	Two-Stage Confined Bubble Curtain System	1	2	Off	22	35
			2	2	Off	22	35

Each of these noise attenuation systems is expected to reduce underwater noise by at least 10dB (FHWA 2012).

Post-PIDP Site Restoration

Upon completion of the PIDP pile testing, the load frames, load test equipment and ancillary piles will be removed. All test piles will be cut off at -20' or 2 ft below the mudline, whichever is lower. FHWA anticipates that pile cut off and removal will use the following general approach:

- The pipe piles will be backfilled with sand up to the cut-off elevation (so that the lower part of the pile will not be left in-situ in the ground in a "hollow" state).
- A cutting torch will be lowered inside the piles/casings to the cut-off elevation.
- The steel pipe piles and steel casings will be cut.
- The cut sections will be lifted out by crane, and removed from site.

PIDP Timeline and Sequencing

The in-river work for the PIDP will take an estimated 3 to 4 months to complete once initiated. The final duration of in-river work will depend on the equipment that the PIDP contractor employs and the number of barges and other vessels that will be available to conduct the work. The target date for the start of the in-river work is March 8, 2012. Test pile installation using an impact hammer is currently scheduled to occur on 7 days between April 26, 2012 and May 23, 2012 with redriving taking place on 7 days between May 4 and June 9, 2012.

Action Area

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area includes the project footprint where the seven test piles and 75 auxiliary piles will be installed as well as the area of the river where increased underwater noise levels and changes in water quality will be experienced. We have used the greatest extent of the 150dB RMS isopleth (see below) to define the outer extent of the action area. We anticipate that all effects of the PIDP will occur within this geographic area. See Figure 2 at the end of this document for a map of the project location.

LISTED SPECIES IN THE ACTION AREA

Endangered shortnose sturgeon (*Acipenser brevirostrum*) occur in the action area. Additionally, three Distinct Population Segments (DPS) of Atlantic sturgeon occur in the action area (Gulf of Maine, New York Bight, and Chesapeake Bay). We published a final listing rule on February 6, 2012 listing four DPSs as endangered (New York Bight, Chesapeake Bay, Carolina, and South Atlantic) and one DPS as threatened (Gulf of Maine). The effective date of the listing is April 6, 2012. At this time, we have not designated or proposed designating critical habitat for shortnose sturgeon or for any DPS of Atlantic sturgeon.

STATUS OF THE SPECIES

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

Shortnose Sturgeon

This section reviews the status of the species rangewide as well as the status of the species in the Hudson River.

Shortnose sturgeon life history

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, isopods), insects, and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell *et al.* 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[1] when the freshwater temperatures increase to 8-9ºC. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987; Crowder *et al.* 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell *et al.* 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell *et al.* 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). 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 *et al.* 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days after hatching in comparison to Savannah River larvae that had longer dispersal rates with

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1 For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the St. John River in Canada. Southern rivers are those south of the Chesapeake Bay.

multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007).   Synder (1988) and Parker (2007) considered individuals to be juvenile when they reached 57mm TL. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while Savannah River fish made this transition on day 41 and 42 (Parker 2007).

The juvenile phase can be subdivided in to young of the year (YOY) and immature/ sub-adults. YOY and sub-adult habitat use differs and is believed to be a function of differences in salinity tolerances. Little is known about YOY behavior and habitat use, though it is believed that they are typically found in channel areas within freshwater habitats upstream of the salt wedge for about one year (Dadswell *et al.* 1984, Kynard 1997). One study on the stomach contents of YOY revealed that the prey items found corresponded to organisms that would be found in the channel environment (amphipods) (Carlson and Simpson 1987). Sub-adults are typically described as age one or older and occupy similar spatio-temporal patterns and habitat-use as adults (Kynard 1997). Though there is evidence from the Delaware River that sub-adults may overwinter in different areas than adults and do not form dense aggregations like adults (ERC Inc. 2007). Sub-adults feed indiscriminately; typical prey items found in stomach contents include aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Dadswell 1979, Carlson and Simpson 1987, Bain 1997).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). 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 spring, as water temperatures reach between 7-9.7ºC (44.6-49.5°F), 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 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). 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 *et al.* 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 15º (46.4-59°F), and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell *et al.* 1984; Hall *et al.* 1991, Kieffer and Kynard 1996, NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-18.0ºC (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell *et al.* 1984). Between 8° (46.4°F) and 12°C (53.6°F), eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell *et al.* 1984; Buckley and Kynard 1985; O'Herron *et al.* 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles or sub-adults tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes and move upstream in spring and feed mostly in freshwater reaches during summer.

Juvenile shortnose sturgeon generally move upstream in spring and summer and move back downstream in fall and winter; however, these movements usually occur in the region above the saltwater/freshwater interface (Dadswell *et al.* 1984; Hall *et al.* 1991). Non-spawning movements include wandering movements in summer and winter (Dadswell *et al.* 1984; Buckley and Kynard 1985; O'Herron *et al.* 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Adult sturgeon occurring in freshwater or freshwater/tidal reaches of rivers in summer and winter often occupy only a few short reaches of the total length (Buckley and Kynard 1985). Summer concentration areas in southern rivers are cool, deep, thermal refugia, where adult and juvenile shortnose sturgeon congregate (Flourney *et al.* 1992; Rogers *et al.* 1994; Rogers and Weber 1995; Weber 1996).

While shortnose sturgeon do not undertake the significant marine migrations seen in Atlantic sturgeon, telemetry data indicates that shortnose sturgeon do make localized coastal migrations. This is particularly true within certain areas such as the Gulf of Maine (GOM) and among rivers in the Southeast. Interbasin movements have been documented among rivers within the GOM 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.

The temperature preference for shortnose sturgeon is not known (Dadswell *et al.* 1984) but shortnose sturgeon have been found in waters with temperatures as low as 2 to 3ºC (35.6-37.4°F) (Dadswell *et al.* 1984) and as high as 34ºC (93.2°F) (Heidt and Gilbert 1978). However, water temperatures above 28ºC (82.4°F) are thought to adversely affect shortnose sturgeon. In the Altamaha River, water temperatures of 28-30ºC (82.4-86°F) 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 (Niklitchek 2001).

Shortnose sturgeon are known to occur at a wide range of depths. A minimum depth of 0.6m (approximately 2 feet) is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30m (98.4 ft) but are generally found in waters less than

20m (65.5 ft) (Dadswell *et al.* 1984; Dadswell 1979). Shortnose sturgeon have also demonstrated tolerance to a wide range of salinities. Shortnose sturgeon have been documented in freshwater (Taubert 1980; Taubert and Dadswell 1980) and in waters with salinity of 30 parts-per-thousand (ppt) (Holland and Yeverton 1973; Saunders and Smith 1978). Mcleave *et al.* (1977) reported adults moving freely through a wide range of salinities, crossing waters with differences of up to 10ppt within a two hour period. The tolerance of shortnose sturgeon to increasing salinity is thought to increase with age (Kynard 1996). Shortnose sturgeon typically occur in the deepest parts of rivers or estuaries where suitable oxygen and salinity values are present (Gilbert 1989); however, shortnose sturgeon forage on vegetated mudflats and over shellfish beds in shallower waters when suitable forage is present.

Status and Trends of Shortnose Sturgeon Rangewide

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Although the original listing notice did not cite reasons for listing the species, a 1973 Resource Publication, issued by the US Department of the Interior, stated that shortnose sturgeon were "in peril…gone in most of the rivers of its former range [but] probably not as yet extinct" (USDOI 1973). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. In the late nineteenth and early twentieth centuries, shortnose sturgeon commonly were taken in a commercial fishery for the closely related and commercially valuable Atlantic sturgeon (*Acipenser oxyrinchus*). More than a century of extensive fishing for sturgeon contributed to the decline of shortnose sturgeon along the east coast. Heavy industrial development during the twentieth century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery; possibly resulting in substantially reduced abundance of shortnose sturgeon populations within portions of the species' ranges (e.g., southernmost rivers of the species range: Santilla, St. Marys and St. Johns Rivers). A shortnose sturgeon recovery plan was published in December 1998 to promote the conservation and recovery of the species (see NMFS 1998). Shortnose sturgeon are listed as "vulnerable" on the IUCN Red List.

Although shortnose sturgeon are listed as endangered range-wide, in the final recovery plan NMFS recognized 19 separate populations occurring throughout the range of the species. These populations are in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). NMFS has not formally recognized distinct population segments (DPS)[2] of shortnose sturgeon under the ESA. Although genetic information within and among shortnose sturgeon occurring in different river systems is largely unknown, life history studies indicate that shortnose sturgeon populations from different river systems are substantially reproductively isolated (Kynard 1997) and, therefore, should be considered discrete. The 1998 Recovery Plan indicates that while genetic information may reveal that interbreeding does not occur between rivers that drain into a common estuary, at this time, such

2 The definition of species under the ESA includes any subspecies of fish, wildlife, or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. To be considered a DPS, a population segment must meet two criteria under NMFS policy. First, it must be discrete, or separated, from other populations of its species or subspecies. Second, it must be significant, or essential, to the long-term conservation status of its species or subspecies. This formal legal procedure to designate DPSs for shortnose sturgeon has not been undertaken.

river systems are considered a single population compromised of breeding subpopulations (NMFS 1998).

Studies conducted since the issuance of the Recovery Plan have provided evidence that suggests that years of isolation between populations of shortnose sturgeon have led to morphological and genetic variation. Walsh *et al.* (2001) examined morphological and genetic variation of shortnose sturgeon in three rivers (Kennebec, Androscoggin, and Hudson). The study found that the Hudson River shortnose sturgeon population differed markedly from the other two rivers for most morphological features (total length, fork length, head and snout length, mouth width, interorbital width and dorsal scute count, left lateral scute count, right ventral scute count). Significant differences were found between fish from Androscoggin and Kennebec rivers for interorbital width and lateral scute counts which suggests that even though the Androscoggin and Kennebec rivers drain into a common estuary, these rivers support largely discrete populations of shortnose sturgeon. The study also found significant genetic differences among all three populations indicating substantial reproductive isolation among them and that the observed morphological differences may be partly or wholly genetic.

Grunwald *et al.* (2002) examined mitochondrial DNA (mtDNA) from shortnose sturgeon in eleven river populations. The analysis demonstrated that all shortnose sturgeon populations examined showed moderate to high levels of genetic diversity as measured by haplotypic diversity indices. The limited sharing of haplotypes and the high number of private haplotypes are indicative of high homing fidelity and low gene flow. The researchers determined that glaciation in the Pleistocene Era was likely the most significant factor in shaping the phylogeographic pattern of mtDNA diversity and population structure of shortnose sturgeon. The Northern glaciated region extended south to the Hudson River while the southern non-glaciated region begins with the Delaware River. There is a high prevalence of haplotypes restricted to either of these two regions and relatively few are shared; this represents a historical subdivision that is tied to an important geological phenomenon that reflects historical isolation. Analyses of haplotype frequencies at the level of individual rivers showed significant differences among all systems in which reproduction is known to occur. This implies that although higher level genetic stock relationships exist (i.e., southern vs. northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

Waldman *et al.* (2002) also conducted mtDNA analysis on shortnose sturgeon from 11 river systems and identified 29 haplotypes. Of these haplotypes, 11 were unique to northern, glaciated systems and 13 were unique to the southern non-glaciated systems. Only 5 were shared between them. This analysis suggests that shortnose sturgeon show high structuring and discreteness and that low gene flow rates indicated strong homing fidelity.

Wirgin *et al.* (2005) also conducted mtDNA analysis on shortnose sturgeon from 12 rivers (St. John, Kennebec, Androscoggin, Upper Connecticut, Lower Connecticut, Hudson, Delaware, Chesapeake Bay, Cooper, Peedee, Savannah, Ogeechee and Altamaha). This analysis suggested that most population segments are independent and that genetic variation among groups was high.

The best available information demonstrates differences in life history and habitat preferences between northern and southern river systems and given the species' anadromous breeding habits, the rare occurrence of migration between river systems, and the documented genetic differences between river populations, it is unlikely that populations in adjacent river systems interbreed with any regularity. This likely accounts for the failure of shortnose sturgeon to repopulate river systems from which they have been extirpated, despite the geographic closeness of persisting populations. This characteristic of shortnose sturgeon also complicates recovery and persistence of this species in the future because, if a river population is extirpated in the future, it is unlikely that this river will be recolonized. Consequently, this Opinion will treat the nineteen separate populations of shortnose sturgeon as subpopulations (one of which occurs in the action area) for the purposes of this analysis.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) in the south and Merrimack and Penobscot rivers in the north (~ several hundred to several thousand adults depending on population estimates used; M. Kieffer, United States Geological Survey, personal communication; Dionne 2010), while the largest populations are found in the Saint John (~18, 000; Dadswell 1979) and Hudson Rivers (~61,000; Bain *et al.* 1998). As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard 1996 indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species population rangewide, or the shortnose sturgeon population in the Northeastern United States exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed.

Threats to shortnose sturgeon recovery rangewide

The Shortnose Sturgeon Recovery Plan (NMFS 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival.

Several natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon. Shortnose sturgeon continue to be taken incidentally in fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979; Dovel *et al.* 1992; Collins *et al.* 1996). In-water or nearshore construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and disturb sturgeon concentration areas. Unless appropriate precautions are made, internal damage and/or death may result from blasting projects with powerful explosives. Hydroelectric dams may affect shortnose sturgeon by restricting habitat, altering river flows or temperatures necessary for successful spawning and/or migration and causing mortalities to fish that become entrained in turbines. Maintenance dredging of Federal navigation channels and other areas can adversely affect or jeopardize shortnose sturgeon populations. Hydraulic dredges can lethally take sturgeon by entraining sturgeon in dredge dragarms and impeller pumps. Mechanical dredges have also been documented to lethally take shortnose sturgeon. In addition to direct effects, dredging operations may also impact shortnose sturgeon by destroying benthic feeding areas, disrupting spawning migrations, and filling spawning habitat with resuspended fine sediments. 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 riverine habitat which can affect shortnose sturgeon. For example, the St. Stephen Power Plant near Lake Moultrie, South Carolina was shut down for several days in June 1991 when large mats of aquatic plants entered the plant's intake canal and clogged the cooling water intake gates. Decomposing plant material in the tailrace canal coupled with the turbine shut down (allowing no flow of water) triggered a low dissolved oxygen water condition downstream and a subsequent fish kill. The South Carolina Wildlife and Marine Resources Department reported that twenty shortnose sturgeon were killed during this low dissolved oxygen event.

Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs) can have substantial deleterious effects on aquatic life including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sinderman 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms (Varanasi 1992) like sturgeon. Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long term effects are not yet known (Ruelle and Henry 1992; Ruelle and Kennlyne 1993). Available data suggests that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

Although there is scant information available on the levels of contaminants in shortnose sturgeon tissues, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectible levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry also determined that heavy metals and organochlorine compounds (i.e. PCBs) accumulate in fat tissues. Although the long term effects of the accumulation of contaminants in fat tissues is not yet known, some speculate that lipophilic toxins could be transferred to eggs and potentially inhibit egg viability. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increases proportionally with fish size (NMFS 1998).

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. Contaminant analysis conducted in 2003 on tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

During summer months, especially in southern areas, shortnose sturgeon must cope with the physiological stress of water temperatures that may exceed 28ºC. Flourney *et al.*(1992) suspected that, during these periods, shortnose sturgeon congregate in river regions which support conditions that relieve physiological stress (i.e., in cool deep thermal refuges). In southern rivers where sturgeon movements have been tracked, sturgeon refrain from moving during warm water conditions and are often captured at release locations during these periods (Flourney *et al.*1992; Rogers and Weber 1994; Weber 1996). The loss and/or manipulation of these discrete refuge habitats may limit or be limiting population survival, especially in southern river systems.

Pulp mill, silvicultural, agricultural, and sewer discharges, as well as a combination of non-point source discharges, which contain elevated temperatures or high biological demand, can reduce dissolved oxygen levels. Shortnose sturgeon are known to be adversely affected by dissolved oxygen levels below 5 mg/L. Shortnose sturgeon may be less tolerant of low dissolved oxygen levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28ºC (82.4°F) (Flourney *et al.* 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

Global climate change may affect shortnose sturgeon in the future. Rising sea level may result in the salt wedge moving upstream in affected rivers, possibly affecting the survival of drifting larvae and YOY shortnose sturgeon that are sensitive to elevated salinity. Similarly, for river systems with dams, YOY may experience a habitat squeeze between a shifting (upriver) salt wedge and a dam causing loss of available habitat for this life stage.

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

Implications of climate change to shortnose sturgeon throughout their range have been speculated, yet no scientific data are available on past trends related to climate effects on this species, and current scientific methods are not able to reliably predict the future magnitude of climate change and associated impacts or the adaptive capacity of this species. While there is a reasonable degree of certainty that certain climate change related effects will be experienced globally (e.g., rising temperatures and changes in precipitation patterns), due to a lack of scientific data, the specific effects to shortnose sturgeon that may result from climate change are not predictable or quantifiable at this time. Information on current effects of global climate change on shortnose sturgeon is not available and while it is speculated that future climate change may affect this species, it is not possible to quantify the extent to which effects may occur. Further analysis on potential effects of climate change on shortnose sturgeon in the action area is included in the Environmental Baseline and Cumulative Effects sections below.

Status of Shortnose Sturgeon in the Hudson River

The action area is limited to the reach of the Hudson River where direct and indirect effects of the Tappan Zee PIDP will be experienced, as described in the "Action Area" section above. As such, this section will discuss the available information related to the presence and status of shortnose sturgeon in the Hudson River and in the action area specifically.

Shortnose sturgeon were first observed in the Hudson River by early settlers who captured them as a source of food and documented their abundance (Bain *et al.* 1998). Shortnose sturgeon in the Hudson River were documented as abundant in the late 1880s (Ryder 1888 in Hoff 1988). Prior to 1937, a few fishermen were still commercially harvesting shortnose sturgeon in the Hudson River; however, fishing pressure declined as the population decreased. During the late 1800s and early 1900s, the Hudson River served as a dumping ground for pollutants that lead to major oxygen depletions and resulted in fish kills and population reductions. During this same time there was a high demand for shortnose sturgeon eggs (caviar), leading to overharvesting.

Water pollution, overfishing, and the commercial Atlantic sturgeon fishery are all factors that may have contributed to the decline of shortnose sturgeon in the Hudson River (Hoff 1988).

In the 1930s, the New York State Biological Survey launched the first scientific analysis that documented the distribution, age, and size of mature shortnose sturgeon in the Hudson River (see Bain *et al.* 1998). In the 1970s, scientific sampling resumed precipitated by the lack of biological data and concerns about the impact of electric generation facilities on fishery resources (see Bain *et al.* 1998). The current population of shortnose sturgeon has been documented by studies conducted throughout the entire range of shortnose sturgeon in the Hudson River (see: Dovel 1979, Hoff *et al.* 1988, Geoghegan *et al.* 1992, Bain *et al.* 1998, Bain *et al.* 2000, Dovel *et al.* 1992).

Several population estimates were conducted throughout the 1970s and 1980s (Dovel 1979; Dovel 1981; Dovel *et al.* 1992). Most recently, Bain *et al.* (1998) conducted a mark recapture study from 1994 through 1997 focusing on the shortnose sturgeon active spawning stock. Utilizing targeted and dispersed sampling methods, 6,430 adult shortnose sturgeon were captured and 5,959 were marked; several different abundance estimates were generated from this sampling data using different population models. Abundance estimates generated ranged from a low of 25, 255 to a high of 80,026; though 61,057 is the abundance estimate from this dataset and modeling exercise that is typically used. This estimate includes spawning adults estimated to comprise 93% of the entire population or 56,708, non-spawning adults accounting for 3% of the population and juveniles 4% (Bain *et al.* 2000). Bain *et al.* (2000) compared the spawning population estimate with estimates by Dovel *et al.* (1992) concluding an increase of approximately 400% between 1979 and 1997. Although fish populations dominated by adults are not common for most species, there is no evidence that this is atypical for shortnose sturgeon (Bain *et al.* 1998).

Woodland and Secor (2007) examined the Bain *et al.* (1998, 2000, 2007) estimates to try and identify the cause of the major change in abundance. Woodland and Secor (2007) concluded that the dramatic increase in abundance was likely due to improved water quality in the Hudson River which allowed for high recruitment during years when environmental conditions were right, particularly between 1986-1991. These studies provide the best information available on the current status of the Hudson River population and suggests that the population is relatively healthy, large, and particular in habitat use and migratory behavior (Bain *et al.* 1998).

Shortnose sturgeon have been documented in the Hudson River from upper Staten Island (RM -3 (rkm -4.8)) to the Troy Dam (RM 155 (rkm 249.5); for reference, the Tappan Zee Bridge is located at RM 27 (rkm 43) (Bain *et al.* 2000, ASA 1980-2002). Prior to the construction of the Troy Dam in 1825, shortnose sturgeon are thought to have used the entire freshwater portion of the Hudson River (NYHS 1809). Spawning fish congregated at the base of Cohoes Falls where the Mohawk River emptied into the Hudson. In recent years (since 1999), shortnose sturgeon have been documented below the Tappan Zee Bridge from June through December (ASA 1999-2002; Dynegy 2003). While shortnose sturgeon presence below the Tappan Zee Bridge had previously been thought to be rare (Bain *et al.* 2000), increasing numbers of shortnose sturgeon have been documented in this area over the last several years (ASA 1999-2002; Dynegy 2003) suggesting that the range of shortnose sturgeon is extending downstream. Shortnose sturgeon were documented as far south as the Manhattan/Staten Island area in June, November and December 2003 (Dynegy 2003).

From late fall to early spring, adult shortnose sturgeon concentrate in a few overwintering areas. Reproductive activity the following spring determines overwintering behavior. The largest overwintering area is just south of Kingston, NY, near Esopus Meadows (RM 86-94, rkm 139-152) (Dovel *et al.* 1992). The fish overwintering at Esopus Meadows are mainly spawning adults. Recent capture data suggests that these areas may be expanding (Hudson River 1999-2002, Dynegy 2003). Captures of shortnose sturgeon during the fall and winter from Saugerties to Hyde Park (greater Kingston reach), indicate that additional smaller overwintering areas may be present (Geoghegan *et al.* 1992). Both Geoghegan *et al.* (1992) and Dovel *et al.* (1992) also confirmed an overwintering site in the Croton-Haverstraw Bay area (RM 33.5 – 38,rkm 54-61). The Tappan Zee Bridge is located approximately 11km (6.5 miles) south of the southern extent of this overwintering area, which is near rkm 54 (RM 33.5). Fish overwintering in areas below Esopus Meadows are mainly thought to be pre-spawning adults. Typically, movements during overwintering periods are localized and fairly sedentary.

In the Hudson River, males usually spawn at approximately 3-5 years of age while females spawn at approximately 6-10 years of age (Dadswell *et al.* 1984; Bain *et al.* 1998). Males may spawn annually once mature and females typically spawn every 3 years (Dovel *et al.* 1992). Mature males feed only sporadically prior to the spawning migration, while females do not feed at all in the months prior to spawning.

In approximately late March through mid-April, when water temperatures are sustained at 8º-9° C (46.4-48.2°F) for several days[3], reproductively active adults begin their migration upstream to the spawning grounds that extend from below the Federal Dam at Troy to about Coeymans, NY (rkm 245-212 (RM 152-131) (Dovel *et al.* 1992). The spawning grounds are located more than 169 km (109 miles) upstream from the Tappan Zee Bridge. Spawning typically occurs at water temperatures between 10-18°C (50-64.4°F) (generally late April-May) after which adults disperse quickly down river into their summer range. Dovel *et al.* (1992) reported that spawning fish tagged at Troy were recaptured in Haverstraw Bay in early June. The broad summer range occupied by adult shortnose sturgeon extends from approximately rkm 38 to rkm 177 (RM 23.5-110). The Tappan Zee Bridge (at rkm 43) is located within the broad summer range.

There is scant data on actual collection of early life stages of shortnose sturgeon in the Hudson River. During a mark recapture study conducted from 1976-1978, Dovel *et al.* (1979) captured larvae near Hudson, NY (rkm 188, RM 117) and young of the year were captured further south near Germantown (RM 106, rkm 171). Between 1996 and 2004, approximately 10 small shortnose sturgeon were collected each year as part of the Falls Shoals Survey (FSS) (ASA 2007). Based upon basic life history information for shortnose sturgeon it is known that eggs adhere to solid objects on the river bottom (Buckley and Kynard 1981; Taubert 1980) and that

3 Based on information from the USGS gage in Albany (gage no. 01359139), in 2002 water temperatures reached 8ºC on April 10 and 15ºC on April 20; 2003 - 8ºC on April 14 and 15ºC on May 19; 2004 - 8ºC on April 17 and 15ºC on May 11. In 2011, the most recent year on record, water temperatures reached 8°C on April 11 and reached 15°C on May 19.

eggs and larvae are expected to be present within the vicinity of the spawning grounds (rkm 245-212, RM 152-131) for approximately four weeks post spawning (i.e., at latest through mid-June). Shortnose sturgeon larvae in the Hudson River generally range in size from 15 to 18 mm (0.6-0.7 inches) TL at hatching (Pekovitch 1979). Larvae gradually disperse downstream after hatching, entering the tidal river (Hoff *et al.* 1988). Larvae or fry are free swimming and typically concentrate in deep channel habitat (Taubert and Dadswell 1980; Bath *et al.* 1981; Kieffer ad Kynard 1993). Given that fry are free swimming and foraging, they typically disperse downstream of spawning/rearing areas. Larvae can be found upstream of the salt wedge in the Hudson River estuary and are most commonly found in deep waters with strong currents, typically in the channel (Hoff *et al.* 1988; Dovel *et al.* 1992). Larvae are not tolerant of saltwater and their occurrence within the estuary is limited to freshwater areas. The transition from the larval to juvenile stage generally occurs in the first summer of life when the fish grows to approximately 2 cm (0.8 in) TL and is marked by fully developed external characteristics (Pekovitch 1979).

Similar to non-spawning adults, most juveniles occupy the broad region of Haverstraw Bay (rkm 55-64.4) RM 34-40 by late fall and early winter(Dovel *et al.* 1992; Geoghegan *et al.* 1992); the Tappan Zee Bridge is located 12 km downstream of the southern edge of the bay. Migrations from the summer foraging areas to the overwintering grounds are triggered when water temperatures fall to 8°C (46.4°F) (NMFS 1998), typically in late November[4]. Juveniles are distributed throughout the mid-river region during the summer and move back into the Haverstraw Bay region during the late fall (Bain *et al.* 1998; Geoghegan *et al.* 1992; Haley 1998).

Shortnose sturgeon are bottom feeders and juveniles may use the protuberant snout to “vacuum” the river bottom. Curran & Ries (1937) described juvenile shortnose sturgeon from the Hudson River as having stomach contents of 85-95% mud intermingled with plant and animal material. Other studies found stomach contents of adults were solely food items, implying that feeding is more precisely oriented. The ventral protrusable mouth and barbells are adaptations for a diet of small live benthic animals. Juveniles feed on smaller and somewhat different organisms than adults. Common prey items are aquatic insects (chironomids), isopods, and amphipods. Unlike adults, mollusks do not appear to be an important part of the diet of juveniles (Bain 1997). As adults, their diet shifts strongly to mollusks (Curran & Ries 1937).

Telemetry data has been instrumental in informing the extent of shortnose sturgeon coastal migrations. Recent telemetry data from the Gulf of Maine indicate shortnose sturgeon in this region undertake significant coastal migrations between larger river systems and utilize smaller coastal river systems during these interbasin movements (Fernandes 2008; UMaine unpublished data). Some outmigration has been documented in the Hudson River, albeit at low levels in comparison to coastal movement documented in the Gulf of Maine and Southeast rivers. Two individuals tagged in 1995 in the overwintering area near Kingston, NY were later recaptured in

4 In 2002, water temperatures at the USGS gage at Hastings-on-Hudson (No. 01376304; the farthest downstream gage on the river) fell to 8°C on November 23. In 2003, water temperatures at this gage fell to 8°C on November 29; In 2010, water temperatures at the USGS gage at West Point, NY (No. 01374019; currently the farthest downstream gage on the river) fell to 8°C on November 23.

the Connecticut River. One of these fish was at large for over two years and the other eight years prior to recapture. As such, it is reasonable to expect some level of movement out of the Hudson into adjacent river systems; however, based on available information it is not possible to predict what percentage of adult shortnose sturgeon originating from the Hudson River may participate in coastal migrations.

The Hudson River supports the largest population of shortnose sturgeon in the U.S. The population has experienced a tremendous increase since the mid-1970s, with some estimates indicating that the population has increased by over 400%. This improvement is thought to have been aided by regulatory mechanisms, including protections provided by the Federal and State ESA listing, as well as improvements in water quality. Additionally, restrictions, and later the prohibition, on fishing for Atlantic sturgeon in New York waters is likely to have reduced the number of shortnose sturgeon mortalities, as this species is thought to have been caught as bycatch in fisheries targeting Atlantic sturgeon. The closure of the state shad fishery, which resulted in the capture, injury and mortality of shortnose sturgeon, is also likely to contribute to continued improvements in the status of shortnose sturgeon in the Hudson River. Based on the best available information, we consider that the Hudson River population of shortnose sturgeon is currently stable at high numbers.

Atlantic Sturgeon

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon and then provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also provide a description of which Atlantic sturgeon DPSs likely occur in the action area and provide information on the use of the action area by Atlantic sturgeon.

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers. comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs[5] (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 3 at the end of this document). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the 5 DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

On February 6, 2012, we published notice in the *Federal Register* that we were listing the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as "endangered," and the Gulf of Maine DPS as "threatened" (77 FR 5880 and 77 FR 5914). The effective date of the listings is

5 To be considered for listing under the ESA, a group of organisms must constitute a "species." A "species" is defined in section 3 of the ESA to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."

April 6, 2012. The DPSs do not include Atlantic sturgeon that are spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

As described below, individuals originating from 3 of the 5 listed DPSs may occur in the action area. Information general to all Atlantic sturgeon as well as information specific to each of the relevant DPSs, is provided below.

Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[6] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007). They are a relatively large fish, even amongst sturgeon species (Pikitch *et al.*, 2005). Atlantic sturgeons are bottom feeders that suck food into a ventrally-located protruding mouth (Bigelow and Schroeder, 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder, 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007).

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; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011). The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing 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 (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). 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

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6 Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn (NEFSC FAQ's, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

(ASMFC, 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clugston, 1997; Caron *et al.*, 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Smith *et al.*, 1982; Dovel and Berggren, 1983; Smith, 1985; ASMFC, 2009), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren, 1983; Smith, 1985; Collins *et al.*, 2000), make rapid spawning migrations upstream, and quickly depart following 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 46-76 cm/s and depths are 3-27 m (Borodin, 1925; Dees, 1961; Leland, 1968; Scott and Crossman, 1973; Crance, 1987; Shirey *et al.* 1999; Bain *et al.*, 2000; Collins *et al.*, 2000; Caron *et al.* 2002; Hatin *et al.* 2002; ASMFC, 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009), and become adhesive shortly after fertilization (Murawski and Pacheco, 1977; Van den Avyle, 1983; Mohler, 2003). Incubation time for the eggs increases as water temperature decreases (Mohler, 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT, 2007).

Larval Atlantic sturgeon (i.e. less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam *et al.* 1996) are assumed to undertake a demersal existence and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.*, 1980; Bain *et al.*, 2000; Kynard and Horgan, 2002; ASMFC, 2009). 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 higher salinity waters as well as low salinity waters (Collins *et al.*, 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton, 1973; Dovel and Berggen, 1983; Waldman *et al.*, 1996; Dadswell, 2006; ASSRT, 2007).

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 (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Welsh *et al.*, 2002; Savoy and Pacileo, 2003; Stein *et al.*, 2004; USFWS, 2004; Laney *et al.*, 2007; Dunton *et al.*, 2010; Erickson *et al.*, 2011; 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 winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 m in 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 apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore 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 (Dovel and Berggren, 1983; Dadswell *et al.*, 1984; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*, 2004; Stein *et al.*, 2004; Wehrell, 2005; Dadswell, 2006; ASSRT, 2007; Laney *et al.*, 2007). These sites may be used as foraging sites and/or thermal refuge.

Determination of DPS Composition in the Action Area

As explained above, the range of all 5 DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. We have determined that Atlantic sturgeon in the action area likely originate from three of the five DPSs at the following frequencies: Gulf of Maine 6%; NYB 92%; and, Chesapeake Bay 2%. These percentages are based on genetic sampling of individuals (n=39) captured within the Hudson River and therefore, represent the best available information on the likely genetic makeup of individuals occurring in the action area. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al*. (2012a).

Distribution and Abundance

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 (Scott and Crossman, 1973; Taub, 1990; Kennebec River Resource Management Plan, 1993; Smith and Clugston, 1997; Dadswell, 2006; ASSRT, 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware, and at least 10,000 females for other spawning stocks (Secor and Waldman, 1999; Secor, 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 16 U.S. rivers are known to support spawning based on available evidence (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT, 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only four rivers (Kennebec, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia where historical records support there used to be fifteen spawning rivers (ASSRT, 2007). Thus, there are substantial gaps in the range between Atlantic sturgeon spawning rivers amongst northern and mid-Atlantic states which could make recolonization of extirpated populations more difficult.

There are no current, published population abundance estimates for any of the currently known spawning stocks. Therefore, there are no published abundance estimates for any of the five DPSs of Atlantic sturgeon. 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 1985-1995 (Kahnle *et al.*, 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson, 2006). Using the data collected from the Hudson River and Altamaha River to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley, 1963; Smith, 1985; Van Eenennaam *et al.*, 1996; Stevenson and Secor, 1999; Collins *et al.* 2000; Caron *et al.*, 2002), the age structure of these populations is not well understood, and stage to stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (e.g., yearlings, subadults, and adults) in a population is lacking. The ASSRT 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).

It is possible, however, to estimate the total number of adults in some other rivers based on the number of mature adults in the Hudson River. We have calculated an estimate of total mature adults and a proportion of subadults for four of the five DPSs. The technique used to obtain these estimates is explained fully in Damon-Randall 2012(b) and is summarized briefly below. We used this method because for these four DPSs, there are: (1) no total population estimates available; (2) with the exception of the Hudson River, no estimates of the number of mature adults; and, (3) no information from directed population surveys which could be used to generate an estimate of the number of spawning adults, total adult population or total DPS population.

Kahnle *et al.* (2007) estimated the number of total mature adults per year in the Hudson River using data from surveys in the 1980s to mid-1990s and based on mean harvest by sex divided by sex specific exploitation rate. While this data is over 20 years old, it is currently the best available data on the abundance of Hudson River origin Atlantic sturgeon. The sex ratio of spawners is estimated to be approximately 70% males and 30% females. As noted above, Kahnle et al. (2007) estimated a mean annual number of mature adults at 596 males and 267 females.

We were able to use this estimate of the adult population in the Hudson River and the rate at which Atlantic sturgeon from the Hudson River are intercepted in certain Northeast commercial fisheries[7] to estimate the number of adults in other spawning rivers. As noted above, the method used is summarized below and explained fully in Damon-Randall 2012(b).

Given the geographic scope of commercial fisheries as well as the extensive marine migrations of Atlantic sturgeon, fish originating from nearly all spawning rivers are believed to be intercepted by commercial fisheries.   An estimate of the number of Atlantic sturgeon captured in certain fisheries authorized by NMFS under Federal FMPs in the Northeast is available (NEFSC 2011). This report indicates that based on observed interactions with Atlantic sturgeon in sink gillnet and otter trawl fisheries from 2006-2010, on average 3,118 Atlantic sturgeon are captured in these fisheries each year. Information in the Northeast Fisheries Observer Program (NEFOP) database, indicates that 25% of captured Atlantic sturgeon are adults (determined as length greater than 150 cm) and 75% are subadults (determined as length less than 150cm). By applying the mixed stock genetic analysis of individuals[8] sampled by the NEFOP and At Sea Monitoring Program (see Damon-Randall *et al*. 2012a) to the bycatch estimate, we can determine an estimate of the number of Hudson River Atlantic sturgeon that are intercepted by these fisheries on an annual basis.

Given the number of observed Hudson River origin Atlantic sturgeon adults taken as bycatch, we can calculate what percentage of Hudson River origin Atlantic sturgeon mature adults these represent. This provides an interception rate. We assume that fish originating in any river in any DPS are equally likely to be intercepted by the observed commercial fisheries; therefore, we can use this interception rate to estimate the number of Atlantic sturgeon in the other rivers of origin. This type of back calculation allows us to use the information we have for the Hudson River and fill in significant data gaps present for the other rivers. Using this method, we have estimated the total adult populations for three DPSs (Gulf of Maine, Chesapeake Bay, and South Atlantic) as follows. We are not able to use this method to calculate an adult population estimate for the Carolina DPS.   Based on the results of the genetic mixed stock analysis, fish originating from the Carolina DPS do not appear in the Northeast Fisheries Observer Program (NEFOP) observer dataset and based on this, as well as genetics information on fish captured in other coastal sampling programs in the Northeast[9] are assumed to not be intercepted in Northeast fisheries. Given the proportion of adults to subadults in the observer database (ratio of 1:3), we can also estimate a number of subadults originating from each DPS. However, this can not be considered an estimate of the total number of subadults because it would only consider those subadults that are of a size vulnerable to captured in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment.

7 Bycatch information was obtained from a report prepared by NMFS' Northeast Fisheries Science Center (NEFSC 2012).
8 Based on the best available information, we expect that 46% of Atlantic sturgeon captured in Northeast commercial fisheries originate from the New York Bight DPS and that 91% of those individuals originate from the Hudson River (see Damon-Randall *et al*. 2012a and Wirgin and King 2011).
9 We reviewed genetics information available for 701 individuals sampled in a variety of coastal sampling programs from Maine to Virginia. Only two fish were identified as Carolina DPS origin (collected in central Long Island Sound) and no fish in the NEFOP database (n=89 for genetic samples) were identified as Carolina DPS origin.

Table 4: Summary of Calculated Population Estimates

DPS	Estimated Mature Adult Population	Estimated Subadults of Size vulnerable to capture in commercial fisheries
GOM	166	498
NYB (Hudson River and Delaware River)	950	2,850
CB	329	987

Threats faced by Atlantic sturgeon throughout their range

Atlantic sturgeon are susceptible to over exploitation given their life history characteristics (e.g., late maturity, dependence on a wide-variety of habitats). Similar to other sturgeon species (Vladykov and Greeley, 1963; Pikitch *et al.*, 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19^{th} and 20^{th} centuries (Taub, 1990; Smith and Clugston, 1997; Secor and Waldman, 1999).

Based on the best available information, NMFS has concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all of the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from the Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, given that Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub, 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing or retaining Atlantic sturgeon or its parts in or from the Exclusive Economic Zone in the course of a commercial fishing activity.

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 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, 2010; 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 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.

Bycatch in U.S. waters is the primary threat faced by all 5 DPSs. At this time, we have an estimate of the number of Atlantic sturgeon captured and killed in sink gillnet and otter trawl fisheries authorized by Federal FMPs (NMFS NEFSC 2011) in the Northeast Region but do not have a similar estimate for Southeast fisheries. We also do not have an estimate of the number of Atlantic sturgeon captured or killed in state fisheries. At this time, we are not able to quantify the effects of other significant threats (e.g., vessel strikes, poor water quality, water availability, dams, and dredging) in terms of habitat impacts or loss of individuals. While we have some information on the number of mortalities that have occurred in the past in association with certain activities (e.g., mortalities in the Delaware and James rivers that are thought to be due to vessel strikes), we are not able to use those numbers to extrapolate effects throughout one or more DPS. This is because of (1) the small number of data points and, (2) lack of information on the percent of incidences that the observed mortalities represent.

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NEFSC 2011). The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%, with the exception of monkfish gear which has a higher mortality rate of approximately 27%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%. Comparing the estimated annual average mortalities to the adult population estimates for each of the 4 DPSs encountered in Northeast fisheries, we estimate that at least 4% of adults from each DPS are being killed as a result of interactions with fisheries authorized by Northeast FMPs each year.

Gulf of Maine DPS

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

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

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

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

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the Gulf of Maine region is currently unknown; however, the documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. The range of Atlantic sturgeon in the Penobscot River is limited by the presence of the Veazie and Great Works Dams. Together these dams prevent Atlantic sturgeon from accessing approximately 29 km of habitat, including the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. While removal of the Veazie and Great Works Dams is anticipated to occur in the near future, the presence of these dams is currently preventing access to significant habitats within the Penobscot River. While Atlantic sturgeon are known to occur in the Penobscot River, it is unknown if spawning is currently occurring or whether the presence of the Veazie and Great Works Dams affects the likelihood of spawning occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

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

There are no empirical abundance estimates for the Gulf of Maine DPS. The Atlantic sturgeon SRT (2007) presumed that the Gulf of Maine DPS was comprised of less than 300 spawning adults per year, based on abundance estimates for the Hudson and Altamaha River riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977-1981 and 1998-2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers, 2004). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized, adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies. As explained above, we have estimated that there is an annual mean of 166 mature adult Atlantic sturgeon in the GOM DPS.

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

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC, 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8 percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King, 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy.(Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.*, in draft).

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

New York Bight DPS
The New York Bight DPS includes the following: 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 (Murawski and Pacheco, 1977; Secor, 2002; ASSRT, 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT, 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

The Hudson River and Estuary extend 504 kilometers from the Atlantic Ocean to Lake Tear of-the-Clouds in the Adirondack Mountains (Dovel and Berggren, 1983). The estuary is 246 km long, beginning at the southern tip of Manhattan Island (rkm 0) and running north to the Troy Dam (rkm 246) near Albany (Sweka *et al.*, 2007). All Atlantic sturgeon habitats are believed to occur below the dam. Therefore, presence of the dam on the river does not restrict access of Atlantic sturgeon to necessary habitats (e.g., for spawning, rearing, foraging, over wintering) (NMFS and USFWS, 1998; ASSRT, 2007).

Use of the river by Atlantic sturgeon has been described by several authors. Briefly, spawning likely occurs in multiple sites within the river from approximately rkm 56 to rkm 182 (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Selection of sites in a given year may be influenced by the position of the salt wedge (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998). The area around Hyde Park (approximately rkm134) has consistently been identified as a spawning area through scientific studies and historical records of the Hudson River sturgeon fishery (Dovel and Berggren, 1983; Van Eenennaam *et al.*, 1996; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Habitat conditions at the Hyde Park site are described as freshwater year round with bedrock, silt and clay substrates and waters depths of 12-24 m (Bain *et al.*, 2000). Bain *et al.* (2000) also identified a spawning site at rkm 112 based on tracking data. The rkm 112 site, located to one side of the river, has clay, silt and sand substrates, and is approximately 21-27 m deep (Bain *et al.*, 2000).

Young-of-year (YOY) have been recorded in the Hudson River between rkm 60 and rkm 148, which includes some brackish waters; however, larvae must remain upstream of the salt wedge because of their low salinity tolerance (Dovel and Berggren, 1983; Kahnle *et al.*, 1998; Bain *et al.*, 2000). Catches of immature sturgeon (age 1 and older) suggest that juveniles utilize the estuary from the Tappan Zee Bridge through Kingston (rkm 43- rkm 148) (Dovel and Berggren, 1983; Bain *et al.*, 2000). Seasonal movements are apparent with juveniles occupying waters from rkm 60 to rkm 107 during summer months and then moving downstream as water temperatures decline in the fall, primarily occupying waters from rkm 19 to rkm 74 (Dovel and Berggren, 1983; Bain *et al.*, 2000). Based on river-bottom sediment maps (Coch, 1986) most juvenile sturgeon habitats in the Hudson River have clay, sand, and silt substrates (Bain *et al.*, 2000). Newburgh and Haverstraw Bays in the Hudson River are areas of known juvenile sturgeon concentrations (Sweka *et al.*, 2007). Sampling in spring and fall revealed that highest catches of juvenile Atlantic sturgeon occurred during spring in soft-deep areas of Haverstraw Bay even though this habitat type comprised only 25% of the available habitat in the Bay (Sweka *et al.*, 2007). Overall, 90% of the total 562 individual juvenile Atlantic sturgeon captured during the course of this study (14 were captured more than once) came from Haverstraw Bay (Sweka *et al.*, 2007). At around 3 years of age, Hudson River juveniles exceeding 70 cm total length begin to migrate to marine waters (Bain *et al.*, 2000).

In general, Hudson River Atlantic sturgeons mature at approximately 11 to 21 years of age (Dovel and Berggren, 1983; ASMFC 1998; Young *et al.* 1998). A sample of 94 pre-spawning adult Atlantic sturgeon from the Hudson River was comprised of males 12 to 19 years old, and females that were 14 to 36 years old (Van Eenennaam *et al.*, 1996). The majority of males were 13 to 16 years old while the majority of females were 16 to 20 years old (Van Eenennaam *et al.*, 1996). These data are consistent with the findings of Stevenson and Secor (1999) who noted that, amongst a sample of Atlantic sturgeon collected from the Hudson River fishery from 1992-1995, growth patterns indicated males grew faster and, thus, matured earlier than females. The spawning season for Hudson River Atlantic sturgeon extends from late spring to early summer (Dovel and Berggren, 1983; Van Eenennaam *et al*., 1996).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800’s is unknown but, has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor, 2002; ASSRT, 2007; Kahnle *et al.*, 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). Kahnle *et al.* (1998; 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid 1970's (Kahnle *et al.*, 1998). A decline appeared to occur in the mid to late 1970's followed by a secondary drop in the late 1980's (Kahnle *et al.*, 1998; Sweka *et al.*, 2007; ASMFC, 2010). Catch-per-unit-effort data suggests that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980’s (Sweka *et al.*, 2007; ASMFC, 2010). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s and while the CPUE is generally higher in the 2000s as compared to the 1990s, given the significant annual fluctuation it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. There is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

In the Delaware River and Estuary, Atlantic sturgeon occur from the mouth of the Delaware Bay to the fall line near Trenton, NJ, a distance of 220 km (NMFS and USFWS, 1998; Simpson, 2008). As is the case in the Hudson River, all historical Atlantic sturgeon habitats appear to be accessible in the Delaware (NMFS and USFWS, 1998; ASSRT, 2007). Recent multi-year studies have provided new information on the use of habitats by Atlantic sturgeon within the Delaware River and Estuary (Brundage, 2007; Simpson, 2008; Brundage and O’Herron, 2009; Fisher, 2009; Calvo *et al.*, 2010; Fox and Breece, 2010).

Historical records from the 1830's indicate Atlantic sturgeon may have spawned as far north as Bordentown, just below Trenton, NJ (Pennsylvania Commission of Fisheries, 1897). Cobb (1899) and Borden (1925) reported spawning occurring between rkm 77 and 130 (Delaware

City, DE to Chester City, PA). Based on recent tagging and tracking studies carried out from 2009-2011, Breece (2011) reports likely spawning locations at rkm 120-150 and rkm 170-190. Mature adults have been tracked in these areas at the time of year when spawning is expected to occur and movements have been consistent with what would be expected from spawning adults. Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat also exists from Tinicum Island (rkm 136) to the fall line in Trenton, NJ (rkm 211). To date, eggs and larvae have not been documented to confirm that actual spawning is occurring in these areas. However, as noted below, the presence of young of the year in the Delaware River provides confirmation that spawning is still occurring in this river.

Sampling in 2009 that targeted YOY resulted in the capture of more than 60 YOY in the Marcus Hook anchorage (rkm 127) area during late October-late November 2009 (Fisher, 2009; Calvo *et al.*, 2010). Twenty of the YOY from one study and six from the second study received acoustic tags that provided information on habitat use by this early life stage (Calvo *et al.*, 2010; Fisher, 2011). YOY used several areas from Deepwater (rkm 105) to Roebling (rkm 199) during late fall to early spring. Some remained in the Marcus Hook area while others moved upstream, exhibiting migrations in and out of the area during winter months (Calvo *et al.*, 2010; Fisher, 2011). At least one YOY spent some time downstream of Marcus Hook (Calvo *et al.*, 2010; Fisher, 2011). Downstream detections from May to August between Philadelphia (rkm 150) and New Castle (rkm 100) suggest non-use of the upriver locations during the summer months (Fisher, 2011). By September 2010, only 3 of 20 individuals tagged by DE DNREC persisted with active tags (Fisher, 2011). One of these migrated upstream to the Newbold Island and Roebling area (rkm 195), but was back down in the lower tidal area within 3 weeks and was last detected at Tinicum Island (rkm 141) when the transmitter expired in October (Fisher, 2011). The other two remained in the Cherry Island Flats (rkm 113) and Marcus Hook Anchorage area (rkm130) until their tags transmissions also ended in October (Fisher, 2011).

The Delaware Estuary is known to be a congregation area for sturgeon from multiple DPSs. Generally, non-natal late stage juveniles (sometimes also referred to as subadults) immigrate into the estuary in spring, establish home range in the summer months in the river, and emigrate from the estuary in the fall (Fisher, 2011). Subadults tagged and tracked by Simpson (2008) entered the lower Delaware Estuary as early as mid-March but, more typically, from mid-April through May. Tracked sturgeon remained in the Delaware Estuary through the late fall departing in November (Simpson, 2008). Previous studies have found a similar movement pattern of upstream movement in the spring-summer and downstream movement to overwintering areas in the lower estuary or nearshore ocean in the fall-winter (Brundage and Meadows, 1982; Lazzari *et al.*, 1986; Shirey *et al.*, 1997; 1999; Brundage and O'Herron, 2009; Brundage and O'Herron in Calvo *et al.*, 2010).

Brundage and O'Herron (in Calvo *et al.* (2010)) tagged 26 juvenile Atlantic sturgeon, including 6 young of the year. For non YOY fish, most detections occured in the lower tidal Delaware River from the middle Liston Range (rkm 70) to Tinicum Island (rkm 141). For non YOY fish, these researchers also detected a relationship between the size of individuals and the movement pattern of the fish in the fall. The fork length of fish that made defined movements to the lower bay and ocean averaged 815 mm (range 651-970 mm) while those that moved towards the bay but were not detected below Liston Range averaged 716 mm (range 505-947 mm), and those that appear to have remained in the tidal river into the winter averaged 524 mm (range 485-566 mm) (Calvo *et al.*, 2010). During the summer months, concentrations of Atlantic sturgeon have been located in the Marcus Hook (rkm 123-129) and Cherry Island Flats (rkm 112-118) regions of the river (Simpson, 2008; Calvo *et al.*, 2010) as well as near Artificial Island (Simpson, 2008). Sturgeon have also been detected using the Chesapeake and Delaware Canal (Brundage, 2007; Simpson, 2008).

Adult Atlantic sturgeon captured in marine waters off of Delaware Bay in the spring were tracked in an attempt to locate spawning areas in the Delaware River, (Fox and Breece, 2010). Over the period of two sampling seasons (2009-2010) four of the tagged sturgeon were detected in the Delaware River. The earliest detection was in mid-April while the latest departure occurred in mid-June (Fox and Breece, 2010). The sturgeon spent relatively little time in the river each year, generally about 4 weeks, and used the area from New Castle, DE (rkm 100) to Marcus Hook (rkm 130) (Fox and Breece, 2010). A fifth sturgeon tagged in a separate study was also tracked and followed a similar timing pattern but traveled farther upstream (to rkm 165) before exiting the river in early June (Fox and Breece, 2010).

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800's indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman, 1999; Secor, 2002). Sampling in 2009 to target young-of- the year (YOY) Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 mm TL (Fisher, 2009) and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron in Calvo *et al.*, 2010). Genetics information collected from 33 of the 2009 year class YOY indicates that at least 3 females successfully contributed to the 2009 year class (Fisher, 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning is still occurring in the Delaware River, the relatively low numbers suggest the existing riverine population is limited in size.

Several threats play a role in shaping the current status and trends observed in the Delaware River and Estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron, 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River; however, at this time we do not have information to quantify this threat or its impact to the population or the New York Bight DPS. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

Summary of the New York Bight DPS

Atlantic sturgeon originating from the New York Bight DPS spawn in the Hudson and Delaware rivers. 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. There are no indications of increasing abundance for the New York Bight DPS (ASSRT, 2009; 2010). 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 (Stein *et al.*, 2004; ASMFC 2007). As explained above, currently 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 1-2% 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. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects are also not able to quantify any effects to habitat.

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 (Lichter *et al.* 2006; EPA, 2008). 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 (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. As explained above, we have estimated that there are an annual mean total of 950 mature adult Atlantic sturgeon in the NYB DPS. 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.

Chesapeake Bay DPS
The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et al.*, 1994; ASSRT, 2007; Greene, 2009). However, conclusive evidence of current spawning is only available for the James River. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

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

Decreased water quality also threatens Atlantic sturgeon of the Chesapeake Bay DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface to volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.*, 2004; ASMFC, 1998; ASSRT, 2007; EPA, 2008). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor, 2005; 2010). At this time we do not have sufficient information to quantify the extent that degraded water quality effects habitat or individuals in the James River or throughout the Chesapeake Bay.

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

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

Summary of the Chesapeake Bay DPS

Spawning for the Chesapeake Bay DPS is known to occur in only the James River. Spawning may be occurring in other rivers, such as the York, but has not been confirmed. There are anecdotal reports of increased sightings and captures of Atlantic sturgeon in the James River. However, this information has not been comprehensive enough to develop a population estimate for the James River or to provide sufficient evidence to confirm increased abundance. Some of the impact from the threats that facilitated the decline of the Chesapeake Bay 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). As explained above, we have estimated that there is an annual mean of 329 mature adult Atlantic sturgeon in the Chesapeake Bay DPS. We do not currently have enough information about any life stage to establish a trend for this DPS.

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

Factors Affecting the Survival and Recovery of Shortnose and Atlantic sturgeon in the Hudson River

There are several activities that occur in the Hudson River that affect individual shortnose and Atlantic sturgeon. Impacts of activities that occur within the action area are considered in the

"Environmental Baseline" section (see page 49). Activities that impact sturgeon in the Hudson River but do not necessarily overlap with the action area are discussed below.

Hudson River Power Plants
The mid-Hudson River provided the cooling water to five large power plants: Indian Point (IP) Units 2 and 3 (RM 43, rkm 69): Roseton Generating Station (RM 66, rkm 107), Danskammer Point Generating Station (RM 66, rkm 107), Bowline Point Generating Station (RM 33, rkm 52.8), and Lovett Generating Station (RM 42, rkm 67). Indian Point is a nuclear generating station; the four other stations are fossil-fueled steam electric stations, and all use once-through cooling. Lovett is no longer operating.

Roseton and Danskammer

In 1998, Central Hudson Gas and Electric Corporation (CHGEC), the operator of the Roseton and Danskammer Point power plants initiated an application with us for an incidental take (ITP) permit under section 10(a)(1)(B) of the ESA.[10] As part of this process CHGEC submitted a Conservation Plan and application for a 10(a)(1)(B) incidental take permit that proposed to minimize the potential for entrainment and impingement of shortnose sturgeon at the Roseton and Danskammer Point power plants. These measures ensure that the operation of these plants will not appreciably reduce the likelihood of the survival and recovery of shortnose sturgeon in the wild. In addition to the minimization measures, a proposed monitoring program was implemented to assess the periodic take of shortnose sturgeon, the status of the species in the project area, and the progress on the fulfillment of mitigation requirements. In December 2000, Dynegy Roseton L.L.C. and Dynegy Danskammer Point L.L.C. were issued incidental take permit no. 1269 (ITP 1269). At the time the ITP was issued, Atlantic sturgeon were not listed under the ESA; therefore, the ITP does not address Atlantic sturgeon.

The ITP exempts the incidental take of 2 shortnose sturgeon at Roseton and 4 at Danskammer Point annually. This incidental take level is based upon impingement data collected from 1972-1998. NMFS determined that this level of take was not likely to appreciably reduce the numbers, distribution, or reproduction of the Hudson River population of shortnose sturgeon in a way that appreciably reduces the ability of shortnose sturgeon to survive and recover in the wild. Since the ITP was issued, the number of shortnose sturgeon impinged has been very low. Dynegy has indicated that this may be due in part to reduced operations at the facilities which results in significantly less water withdrawal and therefore, less opportunity for impingement. While historical monitoring reports indicate that a small number of sturgeon larvae were entrained at Danskammer, no sturgeon larvae have been observed in entrainment samples collected since the ITP was issued. While the ITP does not currently address Atlantic sturgeon, the number of interactions with Atlantic sturgeon at Roseton and Danskammer that have been reported to NMFS since the ITP became effective has been very low.

Indian Point

IP1 operated from 1962 through October 1974. IP2 and IP3 have been operational since 1973

10 CHGEC has since been acquired by Dynegy Danskammer L.L.C. and Dynegy Roseton L.L.C. (Dynegy), thus the current incidental take permit is held by Dynegy. ESA Section 9 prohibits take, among other things, without express authorization through a Section 10 permit or exemption through a Section 7 Incidental Take Statement.

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

Studies to evaluate the effects of entrainment at IP2 and IP3 occurred from the early 1970s through 1987; with intense daily sampling during the spring of 1981-1987. As reported by the Nuclear Regulatory Commission (NRC) in its Final Environmental Impact Statement considering the proposed relicensing of IP2 and IP3 (NRC 2011), entrainment monitoring reports list no shortnose or Atlantic sturgeon eggs or larvae at IP2 or IP3. Given what is known about these life stages (i.e., no eggs expected to be present in the action area; larvae only expected to be found in the deep channel area away from the intakes) and the intensity of the past monitoring, it is reasonable to assume that this past monitoring provides an accurate assessment of past entrainment of sturgeon early life stages. Based on this, it is unlikely that any entrainment of sturgeon eggs and larvae occurred historically.

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

The impingement of shortnose and Atlantic sturgeon at IP2 and IP3 has been documented (NRC 2011). Impingement monitoring occurred from 1974-1990, and during this time period, 21 shortnose sturgeon were observed impinged at IP2. For Unit 3, 11 impinged shortnose sturgeon were recorded. At Unit 2, 251 Atlantic sturgeon were observed as impinged during this time period, with an annual range of 0-118 individuals (peak number in 1975); at Unit 3, 266 Atlantic sturgeon were observed as impinged, with an annual range of 0-153 individuals (peak in 1976). No monitoring of the intakes for impingement has occurred since 1990.

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

The Indian Point facility may be relicensed in the future; if so, it could operate until 2033 and 2035. NRC is currently considering Entergy's application for a new operating license. NRC's proposed action was the subject of a section 7 consultation with NMFS that concluded in October 2011. In our Biological Opinion, we considered the effects of the continued operation of the facility on shortnose sturgeon. We determined that the proposed action was likely to adversely affect, but not likely to jeopardize, the continued existence of shortnose sturgeon. As explained in the "Effects of the Action" section of that Opinion, an average of 5 shortnose sturgeon per year are likely to be impinged at Unit 2 during the extended operating period, with a total of no more than 104 shortnose sturgeon over the 20 year period (dead or alive). Additionally, over the 20 year operating period, an additional 6 shortnose sturgeon (dead or alive) are likely to be impinged at the Unit 1 intakes which will provide service water for the operation of Unit 2. At Unit 3, an average of 3 shortnose sturgeon are likely to be impinged per year during the extended operating period, with a total of no more than 58 shortnose sturgeon (dead or alive) taken as a result of the operation of Unit 3 over the 20 year period. This level of take was exempted through an Incidental Take Statement that applies only to the period when the facility operates under a new operating license (September 28, 2013 through September 28, 2033 for Units 1 and 2; December 12, 2015 through December 12, 2035 for Unit 3). It is likely that the operation of Indian Point continues to cause the impingement, and possible mortality, of some number of individual Atlantic sturgeon in the Hudson River.

Scientific Studies

The Hudson River population of shortnose and Atlantic sturgeon have been the focus of a prolonged history of scientific research. In the 1930s, the New York State Biological Survey launched the first scientific sampling study and documented the distribution, age, and size of mature shortnose sturgeon (Bain *et al.* 1998). In the early 1970s, research resumed in response to a lack of biological data and concerns about the impact of electric generation facilities on fishery resources (Hoff 1988). In an effort to monitor relative abundance, population status, and distribution, intensive sampling of shortnose sturgeon in this region has continued throughout the past forty years. Sampling studies targeting other species, including Atlantic sturgeon, also incidentally capture shortnose sturgeon.

There are currently two shortnose sturgeon scientific research permits issued pursuant to Section 10(a)(1)(A) of the ESA, that authorize research on sturgeon in the Hudson River. The activities authorized under these permits are presented below.

NYDEC's scientific research permit (#16439, which replaces their previously held permit #1547) authorizes DEC to assess the habitat use, population abundance, reproduction, recruitment, age and growth, temporal and spatial distribution, diet selectivity, and contaminant load of shortnose sturgeon in the Hudson River Estuary from New York Harbor (RKM 0) to Troy Dam (RKM 245). NYDEC is authorized to use gillnets and trawls to capture up to 240 and 2,340 shortnose sturgeon in year one through years three and four and five, respectively. Research activities include: capture; measure, weigh; tag with passive integrated transponder (PIT) tags and Floy tags, if untagged; and sample genetic fin clips. A first subset of fish will also be anesthetized and tagged with acoustic transmitters; a second subset will have fin rays sampled for age and growth analysis; and a third subset will have gastric contents lavaged for diet analysis, as well as blood samples taken for contaminants. This permit expires on November 24, 2016.

A permit has been issued to Dynegy[11] (#1580, originally issued as #1254) to evaluate the life history, population trends, and spacio-temporal and size distribution of shortnose sturgeon collected during the annual Hudson River Biological Monitoring Program. Dynegy is authorized to capture up to 82 adults/juveniles annually to measure, weigh, tag, photograph, and collect tissue samples for genetic analyses. Dynegy is also authorized to lethally take up to 40 larvae annually. Permit # 1580 will expire on March 31, 2012. An application for renewal has been received but not yet processed.

Atlantic sturgeon are also the subject of scientific study in the Hudson River and are caught and sampled in both of these studies. NMFS Permits Division is currently assessing the impacts of these studies on Atlantic sturgeon. We do not currently have an estimate of the number of Atlantic sturgeon captured during fisheries sampling in the Hudson River; however, based on the available information, very few Atlantic sturgeon are likely to be killed as a result of interactions with directed or incidental sampling programs, and it is unlikely that scientific sampling is having a significant negative effect on Atlantic sturgeon in the Hudson River.

Impacts of Contaminants and Water Quality

Historically, shortnose sturgeon were rare in the lower Hudson River, likely as a result of poor water quality precluding migration further downstream. However, in the past several years, the water quality has improved and sturgeon have been found as far downstream as the Manhattan/Staten Island area. It is likely that contaminants remain in the water and in the action area, albeit to reduced levels. Sewage, industrial pollutants and waterfront development has likely decreased the water quality in the action area. Contaminants introduced into the water column or through the food chain, eventually become associated with the benthos where bottom dwelling species like sturgeon are particularly vulnerable. Several characteristics of shortnose sturgeon life history including long life span, extended residence in estuarine habitats, and being a benthic omnivore, predispose this species to long term repeated exposure to environmental contaminants and bioaccumulation of toxicants (Dadswell 1979).

Principal toxic chemicals in the Hudson River include pesticides and herbicides, heavy metals, and other organic contaminants such as PAHs and PCBs. Concentrations of many heavy metals also appear to be in decline and remaining areas of concern are largely limited to those near urban or industrialized areas. With the exception of areas near New York City, there currently does not appear to be a major concern with respect to heavy metals in the Hudson River, however metals could have previously affected sturgeon.

PAHs, which are products of incomplete combustion, most commonly enter the Hudson River as a result of urban runoff. As a result, areas of greatest concern are limited to urbanized areas, principally near New York City. The majority of individual PAHs of concern have declined during the past decade in the lower Hudson River and New York Harbor.

PCBs are the principal toxic chemicals of concern in the Hudson River. Primary inputs of PCBs

11 Permit 1580 is issued by NMFS to Dynegy on behalf of "other Hudson River Generators including Entergy Nuclear Indian Point 2, L.L.C., Entergy Nuclear Indian Point 3, L.L.C. and Mirant (now GenOn) Bowline, L.L.C."

in freshwater areas of the Hudson River are from the upper Hudson River near Fort Edward and Hudson Falls, New York. In the lower Hudson River, PCB concentrations observed are a result of both transport from upstream as well as direct inputs from adjacent urban areas. PCBs tend to be bound to sediments and also bioaccumulate and biomagnify once they enter the food chain. This tendency to bioaccumulate and biomagnify results in the concentration of PCBs in the tissue concentrations in aquatic-dependent organisms. These tissue levels can be many orders of magnitude higher than those observed in sediments and can approach or even exceed levels that pose concern over risks to the environment and to humans who might consume these organisms. PCBs can have serious deleterious effects on aquatic life and are associated with the production of acute lesions, growth retardation, and reproductive impairment (Ruelle and Keenlyne 1993). PCB's may also contribute to a decreased immunity to fin rot (Dovel *et al.* 1992). Large areas of the upper Hudson River are known to be contaminated by PCBs, and this is thought to account for the high percentage of shortnose sturgeon in the Hudson River exhibiting fin rot. Under a statewide toxics monitoring program, the NYSDEC analyzed tissues from four shortnose sturgeon to determine PCB concentrations. In gonadal tissues, where lipid percentages are highest, the average PCB concentration was 29.55 parts per million (ppm; Sloan 1981) and in all tissues ranged from 22.1 to 997.0 ppm. Dovel (1992) reported that more than 75% of the shortnose sturgeon captured in his study had severe incidence of fin rot. Given that Atlantic sturgeon have similar sensitivities to toxins as shortnose sturgeon it is reasonable to anticipate that Atlantic sturgeon have been similarly affected. In the Connecticut River, coal tar leachate was suspected of impairing sturgeon reproductive success. Kocan (1993) conducted a laboratory study to investigate the survival of sturgeon eggs and larvae exposed to PAHs, a by-product of coal distillation. Only approximately 5% of sturgeon embryos and larvae survived after 18 days of exposure to Connecticut River coal-tar (i.e., PAH) demonstrating that contaminated sediment is toxic to shortnose sturgeon embryos and larvae under laboratory exposure conditions (NMFS 1998). Manufactured Gas Product (MGP) waste, which is chemically similar to the coal tar deposits found in the Connecticut River, is known to occur at several sites within the Hudson River and this waste may have had similar effects on any sturgeon present in the action area over the years.

Point source discharge (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of sturgeon populations. The compounds associated with discharges can alter the pH of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival.

Heavy usage of the Hudson River and development along the waterfront could have affected shortnose sturgeon throughout the action area. Coastal development and/or construction sites often result in excessive water turbidity, which could influence sturgeon spawning and/or foraging ability.

The Hudson River is used as a source of potable water, for waste disposal, transportation and cooling by industry and municipalities. Rohman *et al.* (1987) identified 183 separate industrial and municipal discharges to the Hudson and Mohawk Rivers. The greatest number of users were in the chemical industry, followed by the oil industry, paper and textile manufactures, sand, gravel, and rock processors, power plants, and cement companies. Approximately 20 publicly owned treatment works discharge sewage and wastewater into the Hudson River. Most of the municipal wastes receive primary and secondary treatment. A relatively small amount of sewage is attributed to discharges from recreational boats.

Water quality conditions in the Hudson River have dramatically improved since the mid-1970s. It is thought that this improvement may be a contributing factor to the improvement in the status of shortnose sturgeon in the river. However, as evidenced above, there are still concerns regarding the impacts of water quality on sturgeon in the river; particularly related to legacy contaminants for which no new discharges may be occurring, but environmental impacts are long lasting (e.g., PCBs, dioxins, coal tar, etc.)

Global climate change

The global mean temperature has risen 0.76ºC (1.36°F) 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%-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. Information on future impacts of climate change in the action area is discussed below.

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^{o}-5^{o}C (5^{o}-9^{o}F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2^{o}C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). 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 freshwater to the North Atlantic (Greene *et al.* 2008, IPCC 2006). 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 2006). The NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). 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 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). 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 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). 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 Hudson 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. Additional information on potential effects of climate change specific to the action area is discussed below. Warming is very likely to continue in the U.S. over the next 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 they will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

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 systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C (0.4°F) 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 (6-8 inches).

Effects of climate change on shortnose and Atlantic sturgeon throughout their range
Shortnose and Atlantic sturgeon have persisted for millions of years and throughout this time have experienced wide variations in global climate conditions and have successfully adapted to these changes. As such, climate change at normal rates (thousands of years) is not thought to have historically been a problem for sturgeon species. Shortnose and Atlantic sturgeon could be affected by changes in river ecology resulting from increases in precipitation and changes in water temperature which may affect recruitment and distribution in these rivers. However, as noted in the "Status of the Species" section above, information on current effects of global climate change on shortnose and Atlantic sturgeon is not available, and while it is speculated that future climate change may affect this species, it is not possible to quantify the extent to which effects may occur.

Information on how climate change will impact the action area is extremely limited. Available information on climate change related effects for the Hudson River largely focuses on effects that rising water levels may have on the human environment. The New York State Sea Level Rise Task Force (Spector in Bhutta 2010) predicts a state-wide sea level rise of 7-52 inches by the end of this century, with the conservative range being about 2 feet. This compares to an average sea level rise of about 1 foot in the Hudson Valley in the past 100 years. Sea level rise is expected to result in the northward movement of the salt wedge. The location of the salt wedge in the Hudson River is highly variable depending on season, river flow, and precipitation so it is unclear what effect this northward shift could have. Potential negative effects include restricting the habitat available for juvenile shortnose sturgeon which are intolerant to salinity and are present exclusively upstream of the salt wedge. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shift that may occur.

Air temperatures in the Hudson Valley have risen approximately 0.5°C (0.9°F) since 1970. In the 2000s, the mean Hudson river water temperature, as measured at the Poughkeepsie Water Treatment Facility, was approximately 2°C (3.6°C) higher than averages recorded in the 1960s (Pisces 2008). However, while it is possible to examine past water temperature data and observe a warming trend, there are not currently any predictions on potential future increases in water temperature in the action area specifically or the Hudson River generally. The Pisces report (2008) also states that temperatures within the Hudson River may be becoming more extreme. For example, in 2005, water temperature on certain dates was close to the maximum ever recorded and also on other dates reached the lowest temperatures recorded over a 53-year period. Other conditions that may be related to climate change that have been reported in the Hudson Valley are warmer winter temperatures, earlier melt-out and more severe flooding. An average increase in precipitation of about 5% is expected; however, information on the effects of an increase in precipitation on conditions in the action area is not available.

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on shortnose sturgeon. Over time, 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. In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations through the area.

As described above, 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. However, there is significant 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. Scientific data on changes in shortnose and Atlantic sturgeon distribution and behavior in the action area is not available. Therefore, it is not possible to say with any degree of certainty whether and how their distribution or behavior in the action area have been or are currently affected by climate change related impacts. Implications of potential changes in the action area related to climate change are not clear in terms of population level impacts, data specific to these species in the action area are lacking. Therefore, any recent impacts from climate change in the action area are not quantifiable or describable to a degree that could be meaningfully analyzed in this consultation. However, given the likely rate of climate change, it is unlikely that there will be any noticeable effects to shortnose or Atlantic sturgeon in the action area, such as changes in distribution or abundance, over the time period considered in this consultation (i.e., March – June 2012). It is also unlikely that shortnose or Atlantic sturgeon in the action area will experience new climate change related effects not already captured in the description of the “status of the species” section above concurrent with the proposed action.

ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area.

As described above, the action area is limited to the area where direct and indirect effects of the PIDP will be experienced and by definition is limited in the Hudson River to the areas where project effects will be experienced. The discussion below focuses on effects of state, federal or private actions, other than the action under consideration, that occur in the action area. Text above considered effects of ongoing activities that are outside the action area but may be affecting individual Atlantic and shortnose sturgeon in the action area.

Federal Actions that have Undergone Formal or Early Section 7 Consultation

The only Federal actions that occur within the action area are research activities authorized pursuant to Section 10 of the ESA (discussed above). No Federal actions that have undergone formal or early section 7 consultation occur in the action area. The Hudson River Federal Navigation Channel is included in the action area; however, this portion of the channel is naturally below the authorized depth of the channel and is not currently maintained by the Army Corps of Engineers.

The existing Tappan Zee Bridge was built in the early 1950s and opened to traffic in 1955. Because the bridge was built prior to the enactment of the Endangered Species Act, no ESA consultation occurred. It is likely that the construction of the existing bridge resulted in some disturbance to aquatic communities and may have affected individual shortnose and Atlantic sturgeon. However, we have no information on construction methodologies or aquatic conditions at the time of construction and are not able to speculate on the effects of construction. The construction of the bridge resulted in the placement of structures in the water where there previously were none and resulted in a loss of benthic habitat. However, given the extremely small benthic footprint of the bridge compared with the size of the Hudson River estuary it is unlikely that this loss of habitat has had significant impacts on shortnose or Atlantic sturgeon. The bridge currently carries approximately 134,000 vehicles per day. The existence of the bridge results in storm water runoff that would not occur but for the existence of the bridge. We have no information on the likely effects of runoff on water quality in the Hudson River, but given the volume of stormwater runoff and best management practices that are in place to minimize impacts to the Hudson River, it is unlikely that there are significant impacts to water quality from the continued operation of the existing bridge.

Summary of Information on shortnose and Atlantic sturgeon in the action area

As discussed in the life history sections above, spawning sites for Atlantic and shortnose sturgeon are located outside of the action area. The distance from the spawning area and the brackish water in the action area makes it extremely unlikely that eggs or larvae of either species would be present in the action area.

Atlantic sturgeon adults are likely to migrate through the action area in the spring as they move from oceanic overwintering sites to upstream spawning sites and then migrate back through the area as they move to lower reaches of the estuary or oceanic areas in the late spring and early summer. Atlantic sturgeon adults are most likely to occur in the action area from May – September. Tracking data from tagged juvenile Atlantic sturgeon indicates that during the spring and summer individuals are most likely to occur within rkm 60-170. During the winter months, juvenile Atlantic sturgeon are most likely to occur between rkm 19 and 74. This seasonal change in distribution may be associated with seasonal movements of the saltwedge and differential seasonal use of habitats. Based on the available data, Atlantic sturgeon may be present in the action area year round. As explained above, Atlantic sturgeon in the action area are likely to have originated from the New York Bight DPS, Chesapeake Bay DPS and Gulf of Maine DPS, with the majority of individuals originating from the New York Bight DPS, and the majority of those individuals originating from the Hudson River.

Shortnose sturgeon juveniles and adults are likely to be present in the action area year round, with the highest numbers present between May and October. At other times of the year, the majority of individuals are expected to be at overwintering sites located outside of the action area. All shortnose sturgeon in the action area are likely to have originated from the Hudson River. Coastal migrations have been documented in the Gulf of Maine, and two individuals tagged in the Hudson River have been caught in the Connecticut River. However, no shortnose sturgeon originating from another river or tagged in another river have been captured or detected in the Hudson River. Based on this, at this time we believe that interbasin movements into the Hudson River are rare.

EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent. Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02; see also 1998 FWS-NMFS Joint Consultation Handbook, pp. 4-26 to 4-28). This Opinion examines the likely effects of the proposed action on shortnose sturgeon and 3 DPSs of Atlantic sturgeon and their habitat in the action area within the context of the species current status, the environmental baseline and cumulative effects. Because there is no critical habitat in the action area, none will be affected.

FHWA is in the process of planning the replacement of the existing Tappan Zee Bridge. A draft Environmental Impact Statement (DEIS) was published on January 23, 2012. Comments on the DEIS's alternatives and impact analysis will be accepted through March 15, 2012, unless the comment period is extended. The DEIS provides information on two potential bridge replacement alternatives. We have considered whether the potential bridge replacement fits the definitions of indirect effects or interrelated or interdependent actions. For the reasons explained below, we have determined that the potential bridge replacement does not meet any of those definitions. The potential replacement of the Tappan Zee Bridge is not an interdependent action because it has independent utility apart from the PIDP, the action under consideration. It is not an interrelated action because the Tappan Zee Bridge replacement project is not part of the PIDP, and it does not rely solely on the PIDP for its justification. While the results from the PIDP will inform some of the construction details in the bridge replacement, should it occur, we cannot conclude that the potential bridge replacement would not occur “but for” the PIDP. Therefore, the potential bridge replacement project is not an interrelated or interdependent activity to the PIDP and its effects will not be considered in this Opinion.

We also considered whether the effects of the Tappan Zee Bridge replacement could be considered as indirect effects of the PIDP. Indirect effects of the PIDP are those effects caused by that project that will occur later in time, but are reasonably certain to occur. If the bridge replacement project is carried out, its effects, generally speaking, would occur later in time compared to the PIDP, but the PIDP would not cause the effects of the bridge replacement. Also, what the effects of the bridge replacement will be is not reasonably certain at this time for several reasons. First, no contracts have been issued and no permits or final approvals have been secured for the bridge replacement project, which sheds uncertainty on both the project itself and its potential effects. Second, while construction alternatives are identified and certain construction information is available in the DEIS, the comment period on the DEIS is still open. There may be changes to the types of alternatives considered and/or technical details provided for each alternative. Finally, the results from the PIDP will inform parts of the construction methodology and some of the mitigation measures to be utilized in any future bridge replacement. The effects of the potential bridge replacement project, therefore, are not reasonably certain at this time for us to consider them in this Opinion. However, a proposal for the future replacement of the bridge will be considered in a subsequent ESA Section 7 consultation.

The proposed action has the potential to affect shortnose and Atlantic sturgeon in several ways: exposure to increased underwater noise resulting from pile installation; changes in water quality; and, altering the abundance or availability of potential prey items. The effects analysis below is organized around these topics.

Effects of Exposure to Increased Underwater Noise

In this section we present: background information on acoustics; a summary of available information on sturgeon hearing; a summary of available information on the physiological and behavioral effects of exposure to underwater noise; and, established thresholds and criteria to consider when assessing impacts of underwater noise. We then present modeling provided by FHWA to establish the noise associated with pile installation and consider the effects of exposure of individual sturgeon to these noise sources. Finally, we consider the impacts of any exposure to individuals.

Basic Background on Acoustics and Fish Bioacoustics

Sound in water follows the same physical principles as sound in air. The major difference is that due to the density of water, sound in water travels about 4.5 times faster than in air (approx. 4900 ft./s vs. 1100 ft./s), and attenuates much less rapidly than in air. As a result of the greater speed, the wavelength of a particular sound frequency is about 4.5 times longer in water than in air (Rogers and Cox 1988; Bass and Clarke 2003).

Frequency (i.e., number of cycles per unit of time, with hertz (Hz) as the unit of measurement) and amplitude (loudness, measured in decibels, or dB) are the measures typically used to describe sound. The hearing range for most fish ranges from a low of 20 Hz to 800 to 1,000 Hz. Most fish in the Hudson River fit into this hearing range, although catfish may hear to about 3,000 or 4,000 Hz and some of the herring-like fishes (and specifically the American shad) can hear to over 100,000 Hz. (Popper *et al.* 2003; Bass and Ladich 2008; Popper and Schilt 2008).

An acoustic field from any source consists of a propagating pressure wave, generated from particle motions in the medium that causes compression and rarefaction. This sound wave consists of both pressure and particle motion components that propagate from the source. All fishes have sensory systems to detect the particle motion component of a sound field, while fishes with a swim bladder (a chamber of air in the abdominal cavity) may also be able to detect the pressure component. Pressure detection is primarily found in fishes where the swim bladder (or other air chamber) lies very close to the ear, whereas fishes in which there is no air chamber near the ear primarily detect particle motion (Popper *et al.* 2003; Popper and Schilt 2009; Popper and Fay 2010). Sturgeon have swim bladders, but they are not located very close to the ear; thus, they are assumed to detect primarily particle motion rather than pressure.

The level of a sound in water can be expressed in several different ways, but always in terms of dB relative to 1 micro-Pascal (µPa). Decibels are a log scale; each 10 dB increase is a ten-fold increase in sound pressure. Accordingly, a 10 dB increase is a 10x increase in sound pressure, and a 20 dB increase is a 100x increase in sound pressure.

The following are commonly used measures of sound:

- Peak sound pressure level (SPL): the maximum sound pressure level (highest level of sound) in a signal measured in dB re 1 µPa.

- Sound exposure level (SEL): the integral of the squared sound pressure over the duration of the pulse (e.g., a full pile driving strike.) SEL is the integration over time of the square of the acoustic pressure in the signal and is thus an indication of the total acoustic energy received by an organism from a particular source (such as pile strikes). Measured in dB re 1µPa^2-s.

- Single Strike SEL: the amount of energy in one strike of a pile.

- Cumulative SEL (cSEL): the energy accumulated over multiple strikes. cSEL indicates the full energy to which an animal is exposed during any kind of signal. The rapidity with which the cSEL accumulates depends on the level of the single strike SEL. The actual level of accumulated energy (cSEL) is the logarithmic sum of the total number of single strike SELs. Thus, cSEL (dB) = Single-strike SEL + $10\log_{10}(N)$; where N is the number of strikes.

- Root Mean Square (RMS): the average level of a sound signal over a specific period of time.

Summary of Available Information on Underwater Noise and Sturgeon

Sturgeon are hearing generalists, and rely primarily on particle motion to detect sounds (Lovell *et al.* 2005). While there are no data both in terms of hearing sensitivity and structure of the auditory system for shortnose or Atlantic sturgeon, there are data for the closely related lake sturgeon (Lovell *et al.*, 2005; Meyer *et al.*, 2010), which for the purpose of considering acoustic impacts can be considered as a surrogate for shortnose and Atlantic sturgeon.

The available data suggest that lake sturgeon can hear sounds from below 100 Hz to 800 Hz (Lovell *et al.*, 2005; Meyer *et al.* 2010). As noted by FHWA, since these two studies examined responses of the ear and did not examine whether fish would behaviorally respond to sounds detected by the ear, it is hard to determine thresholds for hearing (that is, the lowest sound levels that an animal can hear at a particular frequency) using information from these studies.

The swim bladder of sturgeon is relatively small compared to other species (Beregi *et al.*, 2001). While there are no data that correlate effects of noise on fishes and swim bladder size, the potential for damage to body tissues from rapid expansion of the swim bladder likely is reduced in a fish where the structure occupies less of the body cavity, and, thus, is in contact with less body tissue. Although there are no experimental data that enable one to predict the potential effects of sound on sturgeon, the physiological effects of pile driving on sturgeon may actually be less than on other species due to the small size of their swim bladder.

Available Information on Potential Effects of Sound Exposure

Sound is an important source of environmental information for most vertebrates (e.g., Fay and Popper, 2000). Fish are thought to use sound to learn about their general environment, the presence of predators and prey, and, for some species, for acoustic communication. As a consequence, sound is important for fish survival, and anything that impedes the ability of fish to detect a biologically relevant sound could affect individual fish.

Richardson *et al.* (1995) defined different zones around a sound source that could result in different types of effects on fish. There are a variety of different potential effects from any sound, with a decreasing range of effects at greater distances from the source. Thus, very close to the source, effects may range from mortality to behavioral changes. Somewhat further from the source mortality is no longer an issue, and effects range from physiological to behavioral. As one gets even further, the potential for effects declines. The actual nature of effects, and the distance from the source at which they could be experienced will vary and depend on a large number of factors, such as fish hearing sensitivity, source level, how the sounds propagate away from the source and the resultant sound level at the fish, whether the fish stays in the vicinity of the source, the motivation level of the fish, etc.

Underwater sound pressure waves can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). Fish with swim bladders, including shortnose and Atlantic sturgeon are particularly sensitive to underwater impulsive sounds with a sharp sound pressure peak occurring in a short interval of time (Caltrans 2001). As the pressure wave passes through a fish, the swim bladder is rapidly squeezed due to the high pressure, and then rapidly expanded as the under pressure component of the wave passes through the fish. The pneumatic pounding may rupture capillaries in the internal organs as indicated by observed blood in the abdominal cavity, and maceration of the kidney tissues (Caltrans 2001).

There are limited data from other projects to demonstrate the circumstances under which immediate mortality occurs: mortality appears to occur when fish are close (within a few feet to 30 feet) to driving of relatively large diameter piles. Studies conducted by California Department of Transportation (Caltrans, 2001) showed some mortality for several different species of wild fish exposed to driving of steel pipe piles 8 feet in diameter, whereas Ruggerone *et al.* (2008) found no mortality to caged yearling coho salmon (*Oncorhynchus kisutch*) placed as close as 2 ft from a 1.5 foot diameter pile and exposed to over 1,600 strikes. As noted above, species have different tolerances to noise and may exhibit different responses to the same noise source.

Physiological effects that could potentially result in mortality may also occur upon sound exposure as could minor physiological effects that would have no effect on fish survival. Potential physiological effects are highly diverse, and range from very small ruptures of capillaries in fins (which are not likely to have any effect on survival) to severe hemorrhaging of major organ systems such as the liver, kidney, or brain (Stephenson *et al.*, 2010). Other potential effects include rupture of the swim bladder (the bubble of air in the abdominal cavity of most fish species that is involved in maintenance of buoyancy). See Halvorsen *et al.*, 2011 for a review of potential injuries from pile driving.

Effects on body tissues may result from barotrauma or result from rapid oscillations of air bubbles. Barotrauma occurs when there is a rapid change in pressure that directly affects the body gasses. Gas in the swim bladder, blood, and tissue of fish can experience a change in state, expand and contract during rapid pressure changes, which can lead to tissue damage and organ failure (Stephenson *et al.*, 2010).

Related to this are changes that result from very rapid and substantial excursions (oscillations) of the walls of air-filled chambers, such as the swim bladder, striking near-by structures. Under normal circumstances the walls of the swim bladder do not move very far during changes in depth or when impinged upon by normal sounds. However, very intense sounds, and particularly those with very sharp onsets (also called “rise time”) will cause the swim bladder walls to move much greater distances and thereby strike near-by tissues such as the kidney or liver. Rapid and frequent striking (as during one or more sound exposures) can result in bruising, and ultimately in damage, to the nearby tissues.

There is some evidence to suggest that very intense signals may not necessarily have substantial physiological effects and that the extent of effect will vary depending on a number of factors including sound level, rise time of the signal, duration of the signal, signal intensity, etc. For example, investigations on the effects of very high intensity sonar showed no damage to ears and other tissues of several different fish species (Kane *et al.*, 2010). Some studies involving exposure of fish to sounds from seismic air guns, signal sources that have very sharp onset times, as found in pile driving, also did not result in any tissue damage (Popper *et al.*, 2007; Song *et al.*, 2008). However, the extent that results from one study are comparable to another is difficult to determine due to difference in species, individuals, and experimental design. Recent studies of the effects of pile driving sounds on fish showed that there is a clear relationship between onset of physiological effects and single strike and cumulative sound exposure level, and that the initial effects are very small and would not harm an animal (and from which there is rapid and complete recovery), whereas the most intense signals (e.g., >210 dB cumulative SEL) may result in tissue damage that could have long-term mortal effects (Halvorsen *et al.*, 2011; Casper *et al.*, 2011, in prep.)

Criteria for Assessing the Potential for Physiological Effects

The Fisheries Hydroacoustic Working Group (FHWG) was formed in 2004 and consists of biologists from NMFS, USFWS, FHWA, and the California, Washington and Oregon DOTs, supported by national experts on sound propagation activities that affect fish and wildlife species of concern. In June 2008, the agencies signed an MOA documenting criteria for assessing physiological effects of pile driving on fish. The criteria were developed for the acoustic levels at which physiological effects to fish could be expected. It should be noted, that these are onset of physiological effects (Stadler and Woodbury, 2009), and not levels at which fish are necessarily mortally damaged. These criteria were developed to apply to all species, including listed green sturgeon, which are biologically similar to shortnose and Atlantic sturgeon and for these purposes can be considered a surrogate. The interim criteria are:

- Peak SPL: 206 decibels relative to 1 micro-Pascal (dB re 1 µPa).
- cSEL: 187 decibels relative to 1 micro-Pascal-squared second (dB re 1µPa^2-s) for fishes above 2 grams (0.07 ounces).
- cSEL: 183 dB re 1µPa^2-s for fishes below 2 grams (0.07 ounces).

NMFS has relied on these criteria in determining the potential for physiological effects in ESA Section 7 consultations conducted on the US West Coast. At this time, they represent the best available information on the thresholds at which physiological effects to sturgeon are likely to occur. It is important to note that physiological effects may range from minor injuries from which individuals are anticipated to completely recover with no impact to fitness to significant injuries that will lead to death. The severity of injury is related to the distance from the pile being installed and the duration of exposure. The closer to the source and the greater the duration of the exposure, the higher likelihood of significant injury.

In the BA, FHWA presents information on several studies related to assessing physiological effects that have been conducted on a variety of species. We have considered the information presented in the BA and do not find that any of it presents a more comprehensive assessment or set of criteria than the FHWG criteria. FHWA has not proposed using a different set of criteria for assessing the potential for physiological effects and presents their effects analysis in terms of the FHWG criteria.

The studies presented in the BA do demonstrate that different species demonstrate different “tolerances” to different noise sources and that for some species and in some situations, fish can be exposed to noise at levels greater than the FHWG criteria and demonstrate little or no negative effects. As described in the BA, a recent peer-reviewed study from the Transportation Research Board (TRB) of the National Research Council of the National Academies of Science describes a carefully controlled experimental study of the effects of pile driving sounds on fish (Halvorsen *et al.*, 2011). This investigation documented effects of pile driving sounds (recorded by actual pile driving operations) under simulated free-field acoustic conditions where fish could be exposed to signals that were precisely controlled in terms of number of strikes, strike intensity, and other parameters. The study used Chinook salmon and determined that onset of physiological effects that have the potential of reduced fitness, and thus a potential effect on survival, started at above 210 dB re 1 µPa^2·s cSEL. Smaller injuries, such as ruptured capillaries near the fins, which the authors noted were not expected to impact fitness, occurred at lower noise levels. The peak noise level that resulted in physiological effects was about the same as the FHWG criteria.

Based on the available information, for the purposes of this Opinion, we consider the potential for physiological effects upon exposure to 206dB re 1 µPa peak and 187 dB re 1 µPa^2-s cSEL. Use of the 183 dB re 1 µPa^2-s cSEL threshold, is not appropriate for this consultation because all shortnose and Atlantic sturgeon in the action area will be larger than 2 grams. As explained here, physiological effects could range from minor injuries that a fish is expected to completely recover from with no impairment to survival to major injuries that increase the potential for mortality, or result in death.

Available Information for Assessing Behavioral Effects
Results of empirical studies of hearing of fishes, amphibians, birds, and mammals (including humans), in general, show that behavioral responses vary substantially, even within a single species, depending on a wide range of factors, such as the motivation of an animal at a particular time, the nature of other activities that the animal is engaged in when it detects a new stimulus, the hearing capabilities of an animal or species, and numerous other factors (Brumm and Slabbekoorn 2005). Thus, it may be difficult to assign a single criterion above which behavioral responses to noise would occur.

In order to be detected, a sound must be above the “background” level. Additionally, results from some studies suggest that sound may need to be biologically relevant to an individual to elicit a behavioral response. For example, in an experiment on responses of American shad to sounds produced by their predators (dolphins), it was found that if the predator sound is detectable, but not very loud, the shad will not respond (Plachta and Popper 2003). But, if the sound level is raised an additional 8 or 10 dB, the fish will turn and move away from the sound source. Finally, if the sound is made even louder, as if a predator were nearby, the American shad go into a frenzied series of motions that probably helps them avoid being caught. It was speculated by the researchers that the lowest sound levels were those recognized by the American shad as being from very distant predators, and thus, not worth a response. At somewhat higher levels, the shad recognized that the predator was closer and then started to swim away. Finally, the loudest sound was thought to indicate a very near-by predator, eliciting maximum response to avoid predation. Similarly, results from Doksaeter *et al.* (2009) suggest that fish will only respond to sounds that are of biological relevance to them. This study showed no responses by free-swimming herring (*Clupea* spp.) when exposed to sonars produced by naval vessels; but, sounds at the same received level produced by major predators of the herring (killer whales) elicited strong flight responses. Sound levels at the fishes from the sonar in this experiment were from 197 dB to 209 dB (rms) re 1 µPa at 1,000 to 2,000Hz.

For purposes of assessing behavioral effects of pile driving at several West Coast projects, NMFS has employed a 150dB re 1 µPa RMS SPL criterion at several sites including the San Francisco-Oakland Bay Bridge and the Columbia River Crossings. For the purposes of this consultation we will use 150 dB re 1 µPa RMS as a conservative indicator of the noise level at which there is the potential for behavioral effects. That is not to say that exposure to noise levels of 150 dB re 1 µPa RMS will always result in behavioral modifications or that any behavioral modifications will rise to the level of "take" (i.e., harm or harassment) but that there is the potential, upon exposure to noise at this level, to experience some behavioral response. Behavioral responses could range from a temporary startle to avoidance of an ensonified area.

As hearing generalists, sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005), which does not propagate as far from the sound source as does pressure. However, a clear threshold for particle motion was not provided in the Lovell study. In addition, flanking of the sounds through the substrate may result in higher levels of particle motion at greater distances than would be expected from the non-flanking sounds. Unfortunately, data on particle motion from pile driving is not available at this time, and we are forced to rely on sound pressure level criteria. Although we agree that more research is needed, the studies noted above support this as an indication for when behavioral effects could be expected. We are not aware of any studies that have considered the behavior of shortnose or Atlantic sturgeon in response to pile driving noise. However, given the available information from studies on other fish species, we consider 150 dB re 1 µPa RMS to be a reasonable estimate of the noise level at which exposure may result in behavioral modifications.

As noted by FHWA in the BA, there is not an extensive body of literature on effects of anthropogenic sounds on fish behavior, and even fewer studies on effects of pile driving, and many of these were conducted under conditions that make the interpretation of the results uncertain. FHWA suggests that of the studies available, the most useful in assessing the potential effects on behavior of pile driving on fish are those that use seismic airguns, since the air gun sound spectrum is reasonably similar to that of pile driving. The results of the studies, summarized below, suggest that there is a potential for underwater sound of certain levels and frequencies to affect behavior of fish, but that it varies with fish species and the existing hydroacoustic environment. In addition, behavioral response may change over time as fish individuals habituate to the presence of the sound. Behavioral responses to other noise sources, such as noise associated with vessel traffic, and the results of noise deterrent studies, are also summarized below.

Mueller-Blenke *et al.* (2010), attempted to evaluate response of Atlantic cod (*Gadus morhua*) and Dover sole (*Solea solea*) held in large pens to playbacks of pile driving sounds recorded during construction of Danish wind farms. The investigators reported that a few representatives of both species exhibited some movement response, reported as increased swimming speed or freezing to the pile-driving stimulus at peak sound pressure levels ranging from 144 to 156 dB re 1 µPa for sole and 140 to 161 dB re 1 µPa for cod. In the BA, FHWA notes that these results must be interpreted cautiously as fish position was not able to be determined more frequently than once every 80 seconds.

Feist (1991) examined the responses of juvenile pink (*Oncorhyncus gorbuscha*) and chum (*O. keta*) salmon behavior during pile driving operations. Feist had observers watching fish schools in less than 1.5 m water depth and within 2 m of the shore over the course of a pile driving operation. The report gave limited information on the types of piles being installed and did not give pile size. Feist did report that there were changes in distribution of schools at up to 300 m from the pile driving operation, but that of the 973 schools observed, only one showed any overt startle or escape reaction to the onset of a pile strike. There was no statistical difference in the number of schools in the area on days with and without pile driving, although other behaviors changed somewhat.

Any analysis of the Feist data is complicated by a lack of data on pile type, size and source sound level. Without this data, it is very difficult to use the Feist data to help understand how fish would respond to pile driving and whether such sounds could result in avoidance or other behaviors. It is interesting to note that the size of the stocks of salmon never changed, but appeared to be transient, suggesting that normal fish behavior of moving through the study area was taking place no differently during pile driving operations than in quiet periods. This may suggest that the fish observed during the study were not avoiding pile driving operations.

Andersson *et al.* (2007) presents information on the response of sticklebacks (*Gasterosteus aculeatus*), a hearing generalist, to pure tones and broadband sounds from wind farm operations. Sticklebacks responded by freezing in place and exhibiting startle responses at SPLs of 120 dB (re: 1µPa) and less. Purser and Radford (2011) examined the response of three-spined sticklebacks to short and long duration white noise. This exposure resulted in increased startle responses and reduced foraging efficiency, although they did not reduce the total number of prey ingested. Foraging was less efficient due to attacks on non-food items and missed attacks on food items. The SPL of the white noise was reported to be similar (at frequencies between 100 and 1000 Hz) to the noise environment in a shoreline area with recreational speedboat activity. While this does not allow a comparison to the 150 dB re 1 µPa RMS guideline, it does demonstrate that significant noise-induced effects on behavior are possible, and that behaviors other than avoidance can occur.

In the BA, FHWA presents information on studies examining the effects of other anthropogenic sounds on fish including seismic airguns, vessel movements and acoustic deterrent devices. Results from these studies are difficult to compare as they consider different species in different, sometimes artificial, environments. FHWA points out flaws with nearly all of the presented studies making interpretation and applicability of these studies more difficult. Several of the studies (Andersson *et al.* 2007, Purser and Radford 2011, Wysocki *et al.* 2007) support our use of the 150 dB re 1 µPa RMS as a threshold for examining the potential for behavioral responses. We will use 150 dB re 1 µPa RMS as a guideline for assessing when behavioral responses to pile driving noise may be expected. The effect of any anticipated response on individuals will be considered in the effects analysis below.

Effects of Pile Installation on Sturgeon

The effects analysis below relies on the information presented above and considers effects of the three types of pile installation: vibratory, drilling, and impact hammer.

Noise Associated with Installation of Ancillary Piles

Approximately 75 1-2’ diameter piles will be installed. All ancillary piles will be installed with a vibratory hammer. In the BA, FHWA indicates that installation of the 1- to 2-ft diameter ancillary piles is expected to produce acoustic footprints similar to driving sheet piles (163 dB re 1 μPa^2-s SEL_{cum} at a distance of 16-ft or the driving of wood piles with an acoustic footprint of 150 dB re 1 μPa^2-s SEL_{cum} within 10 meters of the pile being driven (Jones and Stokes, 2009)). Installation of the ancillary piles will not result in peak noise levels greater than 206 dB re 1uPa or cSEL greater than 187 dB re 1 μPa^2-s. Thus, there is no potential for physiological effects due to exposure to this noise. Given the extremely small footprint of the area where noise greater than 150 dB re 1 μPa will be experienced (i.e., within 10 meters of the pile being installed), it is extremely unlikely that the behavior of any individual sturgeon would be affected by noise associated with the installation of ancillary piles. Even if a sturgeon was within 10 meters of the pile being installed, we expect that the behavioral response would, at most, be limited to movement outside the area where noise greater than 150 dB re 1 μPa would be experienced (i.e., moving to an area at least 10 meters from the pile). Because this area is very small and it would take very little energy to make these movements, the effect to any individual sturgeon would be insignificant. Based on this analysis, all effects to shortnose and Atlantic sturgeon exposed to noise associated with the installation of ancillary piles with a vibratory hammer will be insignificant and discountable.

Noise Associated with the Drilling and Pinning of Piles
The installation of the 8-foot pile will involve drilling a socket into rock. This will result in an increase in underwater noise for approximately 1.85 hours. FHWA indicates in the BA that noise generated during drilling will be well below the noise levels likely to result in physiological or behavioral effects (i.e., 206 dB re 1 μPa peak and 187 dB re 1 μPa^2-s cSEL for physiological effects and 150 dB re 1 μPa RMS for behavioral effects). This conclusion is supported by analysis completed by NMFS Northwest Region on bridge projects carried out in Washington State where NMFS concluded that oscillating and rotating steel casements for drilled shafts are not likely to elevate underwater sound to a level that is likely to cause injury or noise that would cause adverse changes to fish behavior. Based on this analysis, all effects to shortnose and Atlantic sturgeon exposed to noise associated with the installation of the 8-foot test pile via drilling will be insignificant and discountable.

Noise Associated with Installation of Test Piles by Impact Hammer
All seven test piles will be installed at least partially with impact hammers. These piles (five 4-ft piles; 1 8-ft pile; 1 10-ft pile) will be installed in two sections. The “bottom” section, which is installed first, is likely to be vibrated in. The “top” section will then be installed with an impact hammer. Noise attenuation systems, which are expected to reduce underwater noise by at least 10 dB, will be in place for all test piles installed with impact hammers. Installation of the “bottom” sections of the pile with a vibratory hammer is likely to result in minor increases in underwater noise (see vibratory analysis above) and effects that are insignificant and discountable.

In order to assess the potential effects of the PIDP on shortnose and Atlantic sturgeon, the spatial extent of the hydroacoustic pattern generated by pile driving operations was evaluated by using computer analyses. This information was presented by FHWA in the BA.

In-river acoustic footprints for pile diving were obtained by application of three sound transmission models (MONM, VSTACK, and FWRAM) developed by JASCO. Each of these models accounts for the frequency composition of the pile driving source signal and the physics of acoustic propagation in the water and underlying geological substrates. According to FHWA, this type of modeling takes into full account source characteristics, contributions of propagation in the substrate, the depth of water and attenuation characteristics of shallow water, and the many other site-specific factors that influence the rate of noise attenuation.

Model runs were specifically made to determine at what distance from the pile underwater acoustic pressures and energies resulting from pile driving operations will equal or exceed a peak level of 206 dB re: 1 µPa and when multiple hammer strikes cause in-water cumulative energy levels will exceed 187 dB re: 1µPa^2-s. For each pile size, the runs provided single strike peak pressure levels and multi-strike cumulative energy levels under two sets of assumptions: noise attenuation systems were not installed during piles driving and noise attenuation systems were installed and would reduce broadband noise emissions by 10 dB.

Table 7 provides computed peak pressure levels for various downrange distances (in feet) from the pile driving noise source at which noise is attenuated to 206 dB re 1µPa (peak).

Table 7. Peak Sound Pressure Levels vs. Distance from Pile Driving Source (feet)

Pile Diameter (ft)	Pile Location	206 dB re 1 µPA	200 dB re 1 µPA	194 dB re 1 µPA	188 dB re 1 µPA	182 dB re 1 µPA
PIDP scenarios without noise attenuation						
4	PLT2	31	54	83	203	327
8	PLT3	146	802	1019	1557	1973
10	PLT4	573	1155	1604	2231	2893
PIDP scenarios with 10 dB broadband noise attenuation						
4	PLT2	<10	34	59	100	174
8	PLT3	101	172	277	724	1100
10	PLT4	166	248	773	1191	1693

As can be seen in Table 7, the 206 dB re 1 µPa (peak) pressure levels extend farthest from the pile driving source when a 10-ft diameter pile is driven and no noise attenuation system operates. In this case the distance from the pile to the point at which pressure levels reach 206 dB re 1 µPa (peak) is 573 feet. If it is assumed that a noise attenuation system is installed on the 10-ft diameter piles, and that the attenuation system provides a 10 dB reduction in noise levels, then the distance from the pile to the point at which peak pressure levels reach 206 dB re 1 µPa is 166 feet. For other pile diameters (4-ft and 8-ft), the distances from the pile to the point in the river at which peak pressure levels fall beneath 206 dB re 1 µPa is considerably less than for the 10-ft diameter pile case. It is important to note that pile driving time ranges from one to five hours; the 10 foot pile is expected to involve less than 2 hours of pile driving.

Table 8 presents an estimate of the spatial extent of the cumulative sound exposure level acoustic footprint for each of the four different size piles (4-ft, 6-ft, 8-ft, and 10ft diameter) that would be driven during the PIDP.

Table 8 Approximate Spatial Extent of the 187 dB SEl_{cum} Acoustic footprint vs. Distance (ft) from Pile Driving Source

Pile Diameter	Pile Location	Approx. North-South Extent of 187 dB SEL_{CUM} Footprint*	Approx. East-West Extent of 187 dB SEL_{CUM} Footprint*
Without noise attenuation system			
4 ft	PLT2	2525	2500
8 ft	PLT3	6450	6475
10 ft	PLT4	10025	6175
With attenuation system providing 10 dB noise reduction			
4 ft	PLT2	1375	1650
8 ft	PLT3	3875	3900
10 ft	PLT4	6550	4550
Note: * distance is total length in north-south or east-west direction.			

Similar to the analysis for sound pressure levels, the modeling of cumulative sound exposure levels shows that the 10-foot diameter pile, when driven, would generate the largest cSEL acoustic footprint. Without an operating noise attenuation system, the spatial extent of the 187 dB re: 1µPa^2-s cSEL contour would be approximately 10,025 feet (North-South) by 6175 feet (East-West). With the operation of an effective noise attenuation system (assumed 20 dB broadband noise reduction), the cSEL acoustic footprint would be reduced to 2900 feet (North-South) by 2575 feet (East-West). With a 10db reduction the footprint would be 6,550 feet (North-South) and 4,550 feet (East-West). For smaller diameter piles, the cSEL acoustic footprint would be notably smaller than for the 10-foot diameter piles (see Table 6-3 and Appendix A). Again, it is important to note that it will take less than 5 hours of driving to install each pile, with most piles expected to take 1-3 hours to install.

Table 9 provides estimates of the spatial extent of the 150 dB re 1 µPa rms SPL isopleth that would be generated by driving 4-ft, 8-ft, and 10-ft piles during the PIDP project as well as the spatial extent of that isopleth with noise attenuation measures in place. The reasons that the 8-ft isopleths are slightly larger than the 10-ft isopleths is due to the fact that the 10-ft pile is near the eastern shore of the river and this constrains the east-west diameter of the isopleths.

Table 9 Approximate Spatial Extent of 150 dB re 1 µPa rms SPL Acoustic Footprint

Pile Diameter (ft)	Pile Location	North-South Extent (ft)	East-West Extent (ft)
PIDP scenarios without noise attenuation			
4	PLT2	4,000	4,000
8	PLT3	12,700	9,000
10	PLT4	19,000	8,500
PIDP scenarios with 10dB broadband noise attenuation			
4	PLT2	2,500	2,500
8	PLT3	9,200	8,000

10	PLT4	13,500	7,700

Estimating the Number of Sturgeon Likely to be Exposed to Increased Underwater Noise
Using fish abundance estimates from a 1-year comprehensive gillnet sampling study, FHWA estimated the encounter rate of shortnose sturgeon in the project area as the number of shortnose sturgeon collected per gillnet per hour. From June 2007 – May 2008, 476 gillnets were deployed just upstream of the existing Tappan Zee Bridge (and within the project area for the PIDP) for a total sampling time of 6,479 hours. During this time, 12 shortnose sturgeon were collected: 7 in September and October, 4 in May and June and 1 in August. Based on the observed number of sturgeon collected over 647 gillnet hours, FHWA calculated an encounter rate for shortnose sturgeon in the proposed PIDP demonstration area is 0.02 sturgeon encountered per hour of sampling. The gillnets used for this study consisted of 5 panels, one of each of 1, 2, 3, 4, and 5" stretched mesh. The size of the mesh has a direct relationship to the size of fish caught in the net, with small fish rarely caught in large mesh and large fish rarely caught in small mesh. Shortnose sturgeon of the size that occurs in the action area, would be unlikely to be caught in 1 and 2 inch stretch mesh. Thus, we cannot assume that the entire length of the net fished efficiently for shortnose sturgeon. Since 3/5 of the net likely fished efficiently for sturgeon, it is appropriate to adjust the encounter rate by 0.6 to account for the actual efficiency of the net. This results in an adjusted encounter rate of 0.03 shortnose sturgeon per hour of sampling.

Exposure Potentially Resulting in Physiological Effects – Shortnose sturgeon
To estimate the potential number of shortnose sturgeon exposed to noise levels that could result in physiological effects (i.e., greater than 187 dB re 1 µPa^2-s cSEL, and greater than 206 dB re 1uPa peak), it is necessary to scale the revised gillnet encounter rates from a single gillnet sample to the area encompassed by the isopleth bounding the cumulative sound exposure level (cSEL) of 187dB dB re 1 µPa^2-s (JASCO 2011). FHWA determined the number of shortnose sturgeon that would have been collected if multiple gillnets were deployed side-by-side across the width of the 187-dB isopleth. The length of the gillnet is 125-ft. With no noise attenuation measures in place, the width of the 187-dB isopleth for the pile sizes ranges from about 2,407 to 6,475 ft over the range of pile diameters. With a noise reduction level of 10 dB, the JASCO model indicates that the 187-dB isopleths would range from 2,500 to 6,475 ft in width. Therefore, without noise attenuation measures in place it would require 20-52 gillnets to span the width of the isopleths depending on the size of the pile being driven.

Data collected during the gillnet sampling study suggests that movement by shortnose sturgeon is strongly oriented into or with river currents. During the 2007-2008 gillnet study, shortnose sturgeon were collected with greater frequency in gillnets deployed across the river current vs. with the current. Based on these results, FHWA assumed that sturgeon moved in an upstream or downstream direction through the project area and at a constant rate and would thus be intercepted by gillnets spanning the width of the noise isopleth. FHWA also assumed that catch rates are proportional to shortnose sturgeon abundance, which is a central assumption of most fish-sampling gears, and that sturgeon were uniformly distributed throughout the Tappan Zee region. Under these assumptions, each gillnet would encounter shortnose sturgeon at the same rate allowing the estimates of sturgeon number to be scaled to the width of the isopleth.

Table 10 provides a summary of the number of shortnose sturgeon FHWA estimates to be potentially affected by the PIDP tests at each of the four pile-test locations (PLT-1 – PLT-4) with and without noise attenuation measures. The analysis assumed a 10dB reduction in noise was achieved by the implementation of noise attenuation measures. Using PLT-1 as an example, the width of the 187-dB isopleth for the 4-ft pile test without BMPs would be 2,500 feet or 20 gill nets. At an encounter rate of 0.02 sturgeon per hour, the number of shortnose sturgeon that would pass through the ensonified area during the 4.6 hours required to conduct the test for one 4-ft pile would be: 0.02 shortnose sturgeon per hour * 20 nets*4.6 hrs = 1.84 shortnose sturgeon.

Table 10 FHWA's Estimate of the Number of Shortnose Sturgeon Potentially Exposed to Noise greater than 187 dB re 1uPa (from the 2012 BA)

					With 10 dB BMPs		Without BMPs			With 10 dB BMPs	Without BMPs
Pile reference	**Method of installation**	**Pile type**	**Diameter (ft)**	**Estimated Pile Driving Time (hours)**	**Width of isopleth for 187-dB SELcum (ft)***	**Number of gill nets to span width of isopleth**	**Width of isopleth for 187-dB SELcum (ft)***	**Number of gill nets to span width of isopleth**	**Sturgeon Encounter Rate (fish/hr)****	**Number of shortnose sturgeon potentially affected by the PIDP**	**Number of shortnose sturgeon potentially affected by the PIDP**
PLT1											
PLT1-1	driven	hollow tube	4	4.6	1,650	13	2,500	20	0.02	1.21	1.84
PLT1-2	driven	hollow tube	4	4.6	1,650	13	2,500	20	0.02	1.21	1.84
PLT2											
PLT2-1	driven	hollow tube	4	4.6	1,650	13	2,500	20	0.02	1.21	1.84
PLT2-2	driven	hollow tube	4	4.6	1,650	13	2,500	20	0.02	1.21	1.84
PLT3											
PLT3-1	driven to rock	open-ended	4	1	1,650	13	2,500	20	0.02	0.26	0.40
PLT3-2	driven to rock and socketed	concrete	8	1.85	3,900	31	6,475	52	0.02	1.15	1.92
PLT4											
PLT4-4	driven to rock	concrete	10	1.6	4,500	36	6,175	49	0.02	1.15	1.58
Potential number of sturgeon affected											
Shortnose sturgeon										**7**	**11**
Atlantic sturgeon										**<7**	**<11**

*Width of isopleth determined from hydroacoustic modeling by JASCO
**Encounter rate calculated from gill-net sampling at the project site.

We agree that this approach for estimating the number of shortnose sturgeon likely to occur in the area and thus be exposed to increased underwater noise is reasonable. However, as explained above we have revised the encounter rate to account for the variability in mesh sizes and that only 3/5 of the net had mesh of large enough size to be likely to capture sturgeon. We have rounded up all fractions of fish generated during the modeling to whole fish; a revised table is presented below.

Table 11 Estimate of the Number of Shortnose Sturgeon Potentially Exposed to Noise greater than 187 dB re 1uPa

					With 10 dB BMPs		Without BMPs			With 10 dB BMPs	Without BMPs
Pile reference	Method of installation	Pile type	Diameter (ft)	Estimated Pile Driving Time (hours)	Width of isopleth for 187-dB SELcum (ft)*	Number of gillnets to span width of isopleth	Width of isopleth for 187-dB SELcum (ft)*	Number of gillnets to span width of isopleth	Sturgeon Encounter Rate (fish/hr)**	Number of shortnose sturgeon potentially exposed to noise greater than 187 dB	Number of shortnose sturgeon potentially exposed to noise greater than 187 dB
PLT1											
PLT1-1	driven	hollow tube	4	4.6	1,650	14.2	2,500	20	0.03	2	3
PLT1-2	driven	hollow tube	4	4.6	1,650	14,2	2,500	20	0.03	2	3
PLT2											
PLT2-1	driven	hollow tube	4	4.6	1,650	14.2	2,500	20	0.03	2	3
PLT2-2	driven	hollow tube	4	4.6	1,650	14.2	2,500	20	0.03	2	3
PLT3											
PLT3-1	driven to rock	open-ended	4	1	1,650	14.2	2,500	20	0.03	1	1
PLT3-2	driven to rock and socketed	Concrete	8	1.85	3,900	31.2	6,475	52	0.03	2	3
PLT4											
PLT4-4	driven to rock	concrete	10	1.6	4,500	36	6,175	49.4	0.03	2	3
Potential number of sturgeon exposed to noise levels greater than 187 dB											
Shortnose sturgeon										**13**	**19**

We estimate that the total number of shortnose sturgeon that may be exposed to underwater noise which may cause physiological effects would be 19 fish without the use of any sound attenuation measures. A reduction of 10 dB for all the pile driving at all four sites would reduce the total number to 13 fish. Because BMP testing will be done at certain specific times and locations and not continuously for all test conditions, it is reasonable to assume that the number of potentially affected shortnose sturgeon will fall within the range of 13-19 fish.

FHWA indicates in the BA that physiological effects are likely to be limited to minor injuries. We agree with this assessment as it is likely that sturgeon will begin to avoid the ensonified area prior to getting close enough to experience noise levels that could result in major injuries or mortality. Any shortnose sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience major injuries or mortality. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 25-40% of its total energy. This is expected to cause any sturgeon nearby the pile at the time that pile driving begins to move further away. While sturgeon in the area would be temporarily exposed to noise levels that are likely to result in physiological effects, the short term exposure is likely to result in these injuries being minor. Shortnose sturgeon are known to avoid areas with conditions that would cause physiological effects (e.g., low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The likelihood of exposure to noise levels that could cause major injury or death is further reduced by the short duration of the pile driving activity (no more than 5 hours at a time, for a total of less than 20 hours over 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place). Minor injuries, such as burst capillaries near fins, could be experienced. However, we expect that fish would fully recover from these types of injuries without any effect on their potential survival or future fitness. Effects on behavior are discussed below.

Exposure Potentially Resulting in Physiological Effects – Atlantic sturgeon

No Atlantic sturgeon were captured during the one year gillnet study which consisted of 476 collections over 679 hours; this is likely due to the relatively small mesh size fished which would likely preclude capture of large subadults and adults as well as the relatively low abundance of Atlantic sturgeon in the area. Other available information, including the Long River surveys and tagging and tracking studies conducted by NYDEC and other researchers indicates that juvenile, subadult and adult Atlantic sturgeon are likely to occur in the Tappan Zee region. Population estimates of Hudson River Atlantic sturgeon from the literature and interaction rates in Fall Shoals Program from 2000-2009 of shortnose vs. Atlantic sturgeon suggest that the number of Atlantic sturgeon in the action area would be considerably lower than numbers of shortnose sturgeon. If we had information on the differential gear selectivity for shortnose vs. Atlantic sturgeon we may be able to use the ratio of shortnose to Atlantic sturgeon captured in these studies to determine how many fewer Atlantic sturgeon than shortnose sturgeon we anticipate in the action area. However, the type of information necessary for this type of analysis is not available at this time. Because we expect fewer Atlantic sturgeon in the action area than shortnose sturgeon, it is reasonable to assume that the number of Atlantic sturgeon that could potentially be exposed to cSELs greater than 187 dB re 1 μPa^2-s during the PIDP testing period would be less than the number of shortnose. Therefore, we anticipate that 19 or fewer Atlantic sturgeon will be exposed to noise levels of 187 dB re 1 μPa^2-s cSEL.

Like shortnose sturgeon, we anticipate that physiological effects to individual Atlantic sturgeon are likely to be limited to minor injuries as sturgeon are expected to begin to avoid the ensonified area prior to getting close enough to experience noise levels that could result in major injuries or mortality. Any Atlantic sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience major injuries or mortality. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 40% of its total energy. While they would be temporarily exposed to noise levels that are likely to result in physiological effects, the short term exposure is likely to result in these injuries being minor. Like shortnose sturgeon, Atlantic sturgeon are known to avoid areas with conditions that would cause physiological effects (e.g., low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that Atlantic sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The likelihood of exposure to noise levels that could cause major injury or death is further reduced by the short duration of the pile driving activity (no more than 5 hours at a time, for a total of less than 20 hours over 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place). Minor injuries, such as burst capillaries near fins, could be experienced. However, we expect that fish would fully recover from these types of injuries without any effect on their potential survival or future fitness. Effects on behavior are discussed below.

Exposure Potentially Resulting in Behavioral Effects
It is reasonable to assume that sturgeon, on hearing the pile driving sound, would either not approach the source or move around it. Sturgeon in the area when pile driving begins are expected to leave the area. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 40% of its total energy. These "warning strikes" are designed to cause fish to leave the area before the pile driving begins at full energy. As noted above, since the pile driving sounds are very loud, it is very likely that any sturgeon in the action area will hear the sound, and respond behaviorally, well before they reach a point at which the sound levels exceed the potential for physiological effects, including injury or mortality. Available information suggests that the potential for behavioral effects may begin upon exposure to noise at levels of 150 dB re 1 µPa rms.

When considering the potential for behavioral effects, we need to consider the geographic and temporal scope of any impacted area. For this analysis, we consider the area within the river where noise levels greater than 150 dB re 1 µPa will be experienced and the duration of time that those underwater noise levels could be experienced.

Depending on the pile being driven, the 150 dB re 1 µPa isopleth would extend from 2,500 to 19,000 feet in a north-south direction and 2,500 to 9,000 feet in an east-west direction. The Hudson River at the project site is approximately 3 miles wide (15,840 feet). Even in the worst case, during the installation of the 10 foot pile, only 53% of the river width would have noise levels greater than 150 dB re 1 µPa. Assuming the worst case behaviorally, that sturgeon would avoid an area with underwater noise greater than 150 dB re 1 µPa, there would still be a significant area (47% of the river width, approximately 1.4 miles wide) where fish could pass through unimpeded. Additionally, the maximum amount of time when pile driving will occur is for 5 hours a day. Thus, in the worst case, fish would avoid the ensonfied area for no more than 5 hours a day, for no more than 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place.

After establishing the potential for exposure, we consider what impact this would have on individual shortnose and Atlantic sturgeon. Shortnose and Atlantic sturgeon in the action area are likely to be migrating through the area and may forage opportunistically while migrating. The action area is not known to be an overwintering area or a spawning or nursery site. An individual migrating up or downstream through the action area may change course to avoid the ensonified area; however, given that there will always be at least 47% of the river width (an area 1.4 miles wide) and that any changes in movements would be limited to a 5 hour period when pile driving would be occurring, for no more than 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place, any disturbance is likely to have an insignificant effect on the individual. Potentially, the most sensitive individuals that could be present in the action area would be adult Atlantic sturgeon moving through the action area from the ocean to upstream spawning grounds. However, the availability of river width in which to migrate and the short duration of the pile driving activity make it extremely unlikely that an adult Atlantic sturgeon would not successfully migrate through the action area. As such, it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations.

Based on this analysis, we have determined that it is extremely unlikely that any minor changes in behavior resulting from exposure to increased underwater noise associated with the PIDP will preclude any shortnose or Atlantic sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health.

Summary of effects of noise exposure
In summary, we anticipate that individual sturgeon present in the action area during the time that impact pile driving occurs may make minor adjustments to their behaviors to avoid the ensonified areas. For the reasons outlined above, we expect the effects of any changes in behavior to be insignificant and discountable. We do, however, expect that any sturgeon that do not avoid the ensonified area will be exposed to underwater noise levels that could result in physiological impacts. However, we anticipate that the effects of any exposure will be limited to minor injuries from which all affected individuals will fully recover without any future reduction in survival or fitness. We anticipate that the number of sturgeon that may experience physiological impacts would be limited to 19 or fewer shortnose sturgeon and 19 or fewer than Atlantic sturgeon.

Water Quality

Summary of Available Information on TSS and Sturgeon
Early life stages are most vulnerable to effects of exposure to increased levels of TSS and turbidity. Eggs and immobile larvae can be buried or smothered by suspended solids as they settle out of the water column. As no sturgeon eggs or larvae are expected to be in the action area, effects on these life stages will not be considered further in this Opinion.

Studies of the effects of turbid waters on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993).

The studies reviewed by Burton demonstrated lethal effects to fish at concentrations of 580mg/L to 700,000mg/L depending on species. Sublethal effects have been observed at substantially lower turbidity levels. For example, prey consumption was significantly lower for striped bass larvae tested at concentrations of 200 and 500 mg/L compared to larvae exposed to 0 and 75 mg/L (Breitburg 1988 in Burton 1993). Studies with striped bass adults showed that pre-spawners did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Moiser 1976 and Combs 1979 in Burton 1993). While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, juvenile and adult sturgeon are often documented in turbid water and Dadswell (1984) reports that shortnose sturgeon are more active under lowered light conditions, such as those in turbid waters. As such, shortnose and Atlantic sturgeon are assumed to be as least as tolerant to suspended sediment as other estuarine fish such as striped bass. Based on this, we would expect sturgeon to behave similarly to striped bass upon exposure to increased levels of TSS.

Likelihood of Exposure to Increases in TSS
Sediments may be suspended during pile installation and as a result of propellers scouring the river bottom. Other sources of increased suspended sediment include minor disturbances associated with setting and removing barge and vessel anchors.

Effects of Exposure to Increases in TSS
The background concentration of TSS in the vicinity of the TZB generally varies between 15 and 50 mg/L throughout the year, but reaches much higher levels as a consequence of storm events, such as the recent Hurricane Irene when the extremely high turbidity episode lasted several weeks. Concentrations of total suspended sediment resulting from pile driving would be elevated approximately 5 to 10 mg/L above background within a few hundred feet of the pile being driven (FHWA 2011b -pDEIS). Increases in concentrations of total suspended sediment resulting from construction vessel movement are projected to be less than 5 mg/L. Based on this, any effects to shortnose and Atlantic sturgeon from increased levels of TSS will be insignificant and discountable.

Contaminant Exposure
Resuspension of sediments by prop scour or pile installation may release contaminants into the water column from either sediment pore water or from contaminants that partition from the sediment’s solid phase. However, due to the nature of sediments in the bridge vicinity (i.e., low levels of contamination), measures to be undertaken to limit prop scour by use of shallow draft barges and tugs with a high prop geometry, the use of silt curtains around piles being installed and the limited areal extent of any sediment plume expected to be generated, any mobilization of contaminated sediments is expected to be minor.

In order to evaluate the potential for any resuspension of sediment during the PIDP releasing contaminants in to the water column and the affect both the shortnose or Atlantic sturgeon, FHWA considered the potential release of contaminants compared to the NYSDEC water quality criteria.

Contaminants may be released from the pore water of the sediments, on the resuspended sediments or may dissolve into the water. Although limited SVOCs, pesticide, PCBs and TCDD were detected in the sediments in the area of the PIDP, FHWA has concluded that because of the low detection rates and low concentrations of these contaminants, there would be no measurable increase in the level of these contaminants in the area.

Water quality criteria are developed by EPA for protection of aquatic life. Both acute (short term exposure) and chronic (long term exposure) water quality criteria are developed by EPA based on toxicity data for plants and animals. Often, both saltwater and freshwater criteria are developed, based on the suite of species likely to occur in the freshwater or saltwater environment. For aquatic life, the national recommended toxics criteria are derived using a methodology published in *Guidelines for Deriving Numeric National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. Under these guidelines, criteria are developed from data quantifying the sensitivity of species to toxic compounds in controlled chronic and acute toxicity studies. The final recommended criteria are based on multiple species and toxicity tests. The groups of organisms are selected so that the diversity and sensitivities of a broad range of aquatic life are represented in the criteria values. To develop a valid criterion, toxicity data must be available for at least one species in each of eight families of aquatic organisms. The eight taxa required are as follows: (1) salmonid (e.g., trout, salmon); (2) a fish other than a salmonid (e.g., bass, fathead minnow); (3) chordata (e.g., salamander, frog); (4) planktonic crustacean (e.g., daphnia); (5) benthic crustacean (e.g., crayfish); (6) insect (e.g., stonefly, mayfly); (7) rotifer, annelid (worm), or mollusk (e.g., mussel, snail); and, (8) a second insect or mollusk not already represented. Where toxicity data are available for multiple life stages of the same species (e.g., eggs, juveniles, and adults), the procedure requires that the data from the most sensitive life stage be used for that species.

The result is the calculation of acute (criteria maximum concentration (CMC)) and chronic (criterion continuous concentration (CCC)) criteria. CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly (i.e., for no more than one hour) without resulting in an unacceptable effect. The CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. EPA defines “unacceptable acute effects” as effects that are lethal or immobilize an organism during short term exposure to a pollutant and defines “unacceptable chronic effects” as effects that will impair growth, survival, and reproduction of an organism following long term exposure to a pollutant. The CCC and CMC levels are designed to ensure that aquatic species exposed to pollutants in compliance with these levels will not experience any impairment of growth, survival or reproduction.

Data on toxicity as it relates to shortnose and Atlantic sturgeon is extremely limited. In the absence of species specific chronic and acute toxicity data, the EPA aquatic life criteria represent the best available scientific information. Absent species specific data, NMFS believes it is reasonable to consider that the CMC and CCC criteria are applicable to NMFS listed species as these criteria are derived from data using the most sensitive species and life stages for which information is available. As explained above, a suite of species is utilized to develop criteria and these species are intended to be representative of the entire ecosystem, including marine mammals and sea turtles and their prey. These criteria are designed to not only prevent mortality but to prevent all “unacceptable effects”, which, as noted above, is defined by EPA to include not only lethal effects but also effects that impair growth, survival and reproduction.

Table 12. FHWA's Comparison of Calculated Water Concentrations to NYSDEC TOGS 1.1.1

Contaminant	**Expected Water Concentration (mg/L) based on 10 mg/L sediment Plume (mg/L)**	**Expected Water Concentration (ug/L)**	**NYSDEC Water Quality Criteria (ug/L) (Hudson River classified as Class SB)**	**EPA Water Quality Criteria (CMC and CCC) ug/L**	
Arsenic	1.4E-04	0.14	63	69	36
Cadmium	3.2E-06	0.0032	7.7	40	8.8
Chromium	8.58E-04	0.86	No SB Criteria	1,100	50
Lead	1.37E-03	1.37	8	210	8.1
Mercury	2.46E-05	0.025	0.77	1.8	0.94
Nickel	3.26E-04	0.326	8.2	74	8.2

Expected water concentrations of the contaminants that may be mobilized during the PIDP are well below the NYSDEC and EPA water quality criteria. Based on this reasoning outlined above, for the purposes of this consultation, we consider that the exposure to contaminants at levels below the acute and chronic water quality criteria, will not cause effects that impair growth, survival and reproduction of listed species. Therefore, the effect of any exposure to these contaminants at levels that are far less that the relevant water quality standards, which by design are consistent with, or more stringent than, EPA's aquatic life criteria, will be insignificant on shortnose and Atlantic sturgeon.

Abundance or Availability of Prey

Both shortnose and Atlantic sturgeon feed primarily on benthic invertebrates; these prey species are found on the bottom. The abundance or availability of benthic prey can be impacted in several ways including destruction or displacement as a result of pile installation and burial or smothering due to increased TSS. Any immobile prey located where piles will be installed will be destroyed. The in-river footprint of the PIDP is less than 500 square meters. Given the limited use of this area by foraging sturgeon and the availability of prey in adjacent areas, any effects to shortnose or Atlantic sturgeon resulting from impacts to prey will be insignificant.

Impacts of Vessel Traffic

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 Atlantic sturgeon that are larger and 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; however, it could not be determined if these wounds were inflicted prior to or after the fish's death.

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, assuming that the likelihood of interactions increases with the number of vessels present in an area, NMFS has considered the likelihood that an increase in ship traffic associated with the PIDP would increase the risk of interactions between shortnose sturgeon and ships in the Hudson River generally. Thousands of vessels transit the Hudson River annually, ranging from large cargo ships visiting the port of Albany to small recreational sail and power vessels. Information available from the US Coast Guard indicates that an average of 300 commercial vessels transit the Hudson River during the winter months (USCG 2010). In 2007, the Port of Albany welcomed 72 vessels carrying a total of 768.8 thousand tons of cargo (Port of Albany website). The PIDP will have a limited number of work vessels consisting of two material barges, one crane barge, one tug and smaller boats for personnel movements and the work will be performed for a limited time with limited boat movements. This localized, minor increase in vessel traffic is not likely to increase the risk of interactions between shortnose sturgeon and vessels operating in the Hudson River generally. As such, the increase in risk is likely to be insignificant.

As noted in the 2007 Status Review and the proposed rule, in certain geographic areas 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 in the Delaware and James rivers. Brown and Murphy (2010) examined twenty-eight dead Atlantic sturgeon observed in the Delaware River from 2005-2008. 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 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.). It is important to note that vessel strikes have only been identified as a significant concern in the Delaware and James rivers and current thinking suggests that there may be unique geographic features in these areas (e.g., potentially narrow migration corridors combined with shallow/narrow river channels) that increase the risk of interactions between vessels and Atlantic sturgeon. These geographic features are not present in the Hudson River generally or in the action area specifically. Vessel strike is not considered to be a significant threat in the Hudson River and in contrast to the Delaware and James rivers where several vessel struck individuals are identified each year, very few Atlantic sturgeon with injuries consistent with vessel strike have been observed in the Hudson River.

We have considered the likelihood that an increase in vessel traffic associated with the PIDP would generally increase the risk of interactions between Atlantic sturgeon and vessels in the Hudson River. As explained above, there will be a small, localized increase in vessel traffic. There is likely to be considerable variation in the amount of vessel traffic in the river on a seasonal and daily basis. Annual vessel traffic under the Tappan Zee Bridge between 2000 and 2008, ranged from 8,000 to 16,000 vessels per year (excluding small recreational boats, as no data are available). Given the large volume of traffic on the river and the wide variability in traffic in any given day, the increase in traffic associated with the PIDP is extremely small.

Given the small and localized increase in vessel traffic that would result from the PIDP, it is unlikely that there would be any detectable increase in the risk of vessel strike. As such, effects to Atlantic sturgeon from the increase in vessel traffic are likely to be discountable.

CUMULATIVE EFFECTS

Cumulative effects as defined in 50 CFR 402.02 to include the effects of future State, tribal, local or private actions that are reasonably certain to occur within the action area considered in the biological opinion. Future Federal actions are not considered in the definition of "cumulative effects." Because any future replacement of the Tappan Zee Bridge will be a Federal action and will require a separate consultation pursuant to Section 7 of the ESA, this potential future activity is not considered here. Ongoing Federal actions are considered in the Status of the Species/Environmental Baseline section above. The effects of ongoing actions that occur in the Hudson River, but outside the action area (e.g., other power plants), are discussed in the Status of the Species/Environmental Baseline section above.

Sources of human-induced mortality, injury, and/or harassment of shortnose sturgeon resulting from future State, tribal, local or private actions in the action area that are reasonably certain to occur in the future include incidental takes in state-regulated fishing activities, pollution, global climate change, research activities, and coastal development. While the combination of these activities may affect shortnose sturgeon, preventing or slowing the species' recovery, the magnitude of these effects in the action area is currently unknown. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the status of the species/environmental baseline section.

State Water Fisheries - Future recreational and commercial fishing activities in state waters may take shortnose sturgeon. In the past, it was estimated that up to 100 shortnose sturgeon were captured in shad fisheries in the Hudson River each year, with an unknown mortality rate. Atlantic sturgeon were also incidentally captured in NY state shad fisheries. In 2009, NY State closed the shad fishery indefinitely. That state action is considered to benefit both sturgeon species. Should the shad fishery reopen, shortnose and Atlantic sturgeon would be exposed to the risk of interactions with this fishery. However, NMFS has no indication that reopening the fishery and any effects from it on shortnose and Atlantic sturgeon are not reasonably certain to occur.

Information on interactions with shortnose and Atlantic sturgeon for other fisheries operating in the action area is not available, and it is not clear to what extent these future activities would affect listed species differently than the current state fishery activities described in the Status of the Species/Environmental Baseline section. However, this Opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the status of the species/environmental baseline section.

Pollution and Contaminants – Human activities in the action area causing pollution are reasonably certain to continue in the future, as are impacts from them on shortnose and Atlantic sturgeon. However, the level of impacts cannot be projected. Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from coastal development, groundwater discharges, and industrial development. Chemical contamination may have an effect on listed species reproduction and survival. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the status of the species/environmental baseline section.

In the future, *global climate change* is expected to continue and may impact shortnose sturgeon and their habitat in the action area. However, as noted in the "Status of the Species/Environmental Baseline" section above, given the likely rate of change associated with climate impacts (i.e., multiple decade to century scale), it is unlikely that climate related impacts will have a significant effect on the status of shortnose sturgeon over the temporal scale of the proposed action (i.e., to be completed during the spring of 2012) or that in this time period, the abundance, distribution, or behavior of these species in the action area will change as a result of climate change related impacts.

INTEGRATION AND SYNTHESIS OF EFFECTS

NMFS has estimated that the proposed PIDP, to be carried out in 2012, will result in the exposure of 19 or fewer shortnose sturgeon and 19 or fewer Atlantic sturgeon to underwater noise that may result in physiological effects. No mortality is anticipated and all affected sturgeon are expected to recover from any injuries without any reduction in fitness or impact on survival. Additionally, any shortnose and Atlantic sturgeon present in the action area when impact pile driving is occurring may be exposed to levels of underwater noise which may alter their normal behaviors. These behaviors are expected to occur in areas where underwater noise is elevated above 150 dB re 1 μPa RMS. Behavioral changes could range from a startle response followed by resumption of normal behaviors to complete avoidance of the ensonified area over the duration that the elevated noise will be experienced. As explained fully above, effects of this temporary behavioral disturbance will be insignificant and discountable. As explained in the

"Effects of the Action" section, all other effects to shortnose sturgeon, including to their prey and from the alterations to water quality, will be insignificant or discountable.

In the discussion below, NMFS considers whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of shortnose sturgeon and each of 3 DPSs of Atlantic sturgeon. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of shortnose sturgeon. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Below, for shortnose sturgeon, the listed species that may be affected by the proposed action, NMFS summarizes the status of the species and considers whether the proposed action will result in reductions in reproduction, numbers or distribution of that species and then considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of that species, as those terms are defined for purposes of the federal Endangered Species Act.

Shortnose sturgeon
Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

The Hudson River population of shortnose sturgeon is the largest in the United States. Historical estimates of the size of the population are not available as historic records of sturgeon in the river did not discriminate between Atlantic and shortnose sturgeon. Population estimates made by Dovel *et al.* (1992) based on studies from 1975-1980 indicated a population of 13,844 adults. Bain *et al.* (1998) studied shortnose sturgeon in the river from 1993-1997 and calculated an adult population size of 56,708 with a 95% confidence interval ranging from 50,862 to 64,072 adults.

Bain determined that based on sampling effort and methodology his estimate is directly comparable to the population estimate made by Dovel *et al.* Bain concludes that the population of shortnose sturgeon in the Hudson River in the 1990s was 4 times larger than in the late 1970s. Bain states that as his estimate is directly comparable to the estimate made by Dovel, this increase is a "confident measure of the change in population size." Bain concludes that the Hudson River population is large, healthy and particular in habitat use and migratory behavior. Woodland and Secor (2007) conducted studies to determine the cause of the increase in population size. Woodland and Secor captured 554 shortnose sturgeon in the Hudson River and made age estimates of these fish. They then hindcast year class strengths and corrected for gear selectivity and cumulative mortality. The results of this study indicated that there was a period of high recruitment (31,000 – 52,000 yearlings) in the period 1986-1992 which was preceded and succeeded by 5 years of lower recruitment (6,000 – 17,500 yearlings/year). Woodland and Secor reports that there was a 10-fold recruitment variability (as measured by the number of yearlings produced) over the 20-year period from the late 1970s to late 1990s and that this pattern is expected in a species, such as shortnose sturgeon, with periodic life history characterized by delayed maturation, high fecundity and iteroparous spawning, as well as when there is variability in interannual hydrological conditions. Woodland and Secor examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults.

The Hudson River population of shortnose sturgeon has exhibited tremendous growth in the 20-year period between the late 1970s and late 1990s. Woodland and Secor conclude that this is a robust population with no gaps in age structure. Lower recruitment that followed the 1986-1992 period is coincident with record high abundance suggesting that the population may be reaching carrying capacity. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, add uncertainty to any determination on the status of this species as a whole. Based on the best available information, NMFS believes that the status of shortnose sturgeon throughout their range is at best stable, with gains in populations such as the Hudson, Delaware and Kennebec offsetting the continued decline of southern river populations, and at worst declining.

As described in the Status of the Species/Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Hudson River are affected by impingement at water intakes, habitat alteration, bycatch in commercial and recreational fisheries, water quality and in-water construction activities. It is difficult to quantify the number of shortnose sturgeon that may be killed in the Hudson River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions NMFS obtains some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Hudson River each year, with little if any mortality. NMFS has no reports of interactions or mortalities of shortnose sturgeon in the Hudson River resulting from dredging or other in-water construction activities. NMFS also has no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Hudson River since the 1970s when the CWA was implemented. NMFS also has anecdotal evidence that shortnose sturgeon are expanding their range in the Hudson River and fully utilizing the river from the Manhattan area upstream to the Troy Dam, which suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Roseton and Danskammer plants is regularly reported to NMFS. Since reporting requirements were implemented in 2000, less than the exempted number of takes (6 total for the two facilities) have occurred each year. Despite these ongoing threats, there is evidence that the Hudson River population of shortnose sturgeon experienced tremendous growth between the 1970s and 1990s and that the population is now stable at high numbers. Shortnose sturgeon in the Hudson River continue to experience anthropogenic and natural sources of mortality. However, NMFS is not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Hudson River population. Also, as discussed above, NMFS does not expect shortnose sturgeon to experience any new effects associated with climate change during the 2-3 month duration of the proposed action. As such, NMFS expects that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the 2-3 month duration of the proposed action.

NMFS has estimated that the proposed PIDP will result in injury to no more than 19 shortnose sturgeon. No mortality is anticipated. Physiological effects are expected to be limited to minor injuries that will not impair the fitness of any individuals or affect survival. Behavioral responses are expected to be temporally and spatially limited to the area and time when underwater noise levels are greater than 150dB RMS and as such will be limited to only several hours at a time, and always less than 5 hours per day. The potential for behavioral responses is limited to the time when impact pile driving will take place and is therefore limited to a period of less than 5 hours for no more than 7 non-consecutive days during test pile installation and less than a minute during each of 7 days when redriving takes place. Behavioral responses could range from a temporary startle to avoidance of the ensonified area. We have determined that any behavioral responses, including in the worst case, complete avoidance of the ensonified area, would have insignificant and discountable effects to individuals. This is because while individuals may be displaced from, or avoid, the ensonified area: (1) there will always be at least 47% of the river width (an area 1.4 miles wide) with noise levels less than 150 dB re 1uPa RMS; (2) any changes in movements would be limited to a 5 hour period when pile driving would be occurring, for no more than 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place; (3) it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations; (4) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health, and, (5) any minor changes in behavior resulting from exposure to increased underwater noise associated with the

PIDP will preclude any shortnose sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected.

The survival of any shortnose sturgeon will not be affected by the proposed PIDP. As such, there will be no reduction in the numbers of shortnose sturgeon in the Hudson River and no change in the status of this population or its stable trend.

Reproductive potential of the Hudson population is not expected to be affected in any way. As all sturgeon are anticipated to fully recover from any physiological impacts and any behavioral responses will not delay or disrupt any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, the proposed action will not affect spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Any effects to distribution will be minor and temporary and limited to the temporal and geographic scale of the area ensonified by pile driving operations.

Based on the information provided above, the exposure of shortnose sturgeon to the effects of the PIDP will not appreciably reduce the likelihood of survival of this species (i.e., it will not increase the risk of extinction faced by this species) given that: (1) the population trend of shortnose sturgeon in the Hudson River is stable; (2) there will be no mortality and therefore, no reduction in the numbers shortnose sturgeon in the Hudson River or the species as a whole; (3) there will be no effect to the fitness of any individuals and no effect on reproductive output of the Hudson River population of shortnose sturgeon or the species as a whole; (4) and, the action will have only a minor and temporary effect on the distribution of shortnose sturgeon in the action area (related to movements around the esonified area) and no effect on the distribution of the species throughout its range.

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

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in no reduction in the number of shortnose sturgeon in the Hudson River and since it will not affect the overall distribution of shortnose sturgeon other than to cause minor temporary adjustments in movements in the action area. The proposed action will not utilize shortnose sturgeon for recreational, scientific or commercial purposes or affect the adequacy of existing regulatory mechanisms to protect this species. The proposed action is not likely to result in any mortality or reductions in fitness or future reproductive output and therefore, there is not expected to affect the persistence of the Hudson River population of shortnose sturgeon or the species as a whole. There will not be a change in the status or trend of the Hudson River population, which is stable at high numbers. As it will not affect the status or trend of this population, it will not affect the status or trend of the species as a whole. As there will be no reduction in numbers or future reproduction, the action would not cause any reduction in the likelihood of improvement in the status of shortnose sturgeon throughout their range. The effects of the proposed action will not delay the recovery timeframe or otherwise decrease the likelihood of recovery since the action will not cause any mortality or reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

Atlantic sturgeon

Determination of DPS Composition
As explained above, the proposed action is likely to result in the injury of 19 or fewer Atlantic sturgeon. We have considered the best available information to determine from which DPSs these individuals are likely to have originated. Using mixed stock analysis explained above, we have determined that Atlantic sturgeon in the action area likely originate from three DPSs at the following frequencies: Gulf of Maine 6%; NYB 92%; and, Chesapeake Bay 2% . As such, of the 19 or fewer Atlantic sturgeon that may experience minor injuries during the course of the PIDP. Based on the mixed stock analysis, we expect that 17 of these Atlantic sturgeon would be New York Bight DPS origin, and that 1 will originate from the Chesapeake Bay DPS and 1 will originate from the Gulf of Maine DPS. Below, we consider these effects to each of the 3 DPSs.

Gulf of Maine DPS
Individuals originating from the GOM DPS are likely to occur in the action area. The GOM DPS has been listed as threatened. While Atlantic sturgeon occur in several rivers in the GOM DPS, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available. We have estimated, based on fishery-dependent data, that there are approximately 166 mature adults in the GOM DPS. Approximately 1/3 of adults are likely to spawn each year. GOM origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. While there are some indications that the status of the GOM DPS may be

improving, there is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

NMFS has estimated that the proposed PIDP will result in injury to 19 or fewer Atlantic sturgeon of which 1 is expected to be a GOM DPS Atlantic sturgeon. The following analysis applies to anticipated effects on 1 individual from the GOM DPS, but given the nature of the effects, it applies equally well to the worst case, but unlikely, scenario of all 19 being from the GOM DPS. No mortality is anticipated. Physiological effects are expected to be limited to minor injuries that will not impair the fitness of any individuals or affect survival. Behavioral responses are expected to be temporally and spatially limited to the area and time when underwater noise levels are greater than 150dB RMS and as such will be limited to only several hours at a time, and always less than 5 hours per day. The potential for behavioral responses is limited to the time when impact pile driving will take place and is therefore limited to a period of less than 5 hours for no more than 7 non-consecutive days during test pile installation and less than a minute during each of 7 days when redriving takes place. Behavioral responses could range from a temporary startle to avoidance of the ensonified area. We have determined that any behavioral responses, including in the worst case, complete avoidance of the ensonified area, would have insignificant and discountable effects to individuals. This is because while individuals may be displaced from, or avoid, the ensonified area: (1) there will always be at least 47% of the river width (an area 1.4 miles wide) with noise levels less than 150 dB re 1uPa RMS; (2) any changes in movements would be limited to a 5 hour period when pile driving would be occurring, for no more than 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place; (3) it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations; (4) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health, and, (5) any minor changes in behavior resulting from exposure to increased underwater noise associated with the PIDP will preclude any GOM DPS Atlantic sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected.

The survival of any GOM DPS Atlantic sturgeon will not be affected by the proposed PIDP. As such, there will be no reduction in the numbers of GOM DPS Atlantic sturgeon and no change in the status of this species or its trend.

Reproductive potential of the GOM DPS is not expected to be affected in any way. As all sturgeon are anticipated to fully recover from any physiological impacts and any behavioral responses will not delay or disrupt any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, as the proposed action will occur outside of the rivers where GOM DPS fish are expected to spawn (i.e., the Kennebec River in Maine), the proposed action will not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede GOM DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporal and geographic scale of the area ensonified by pile driving operations.

Based on the information provided above, the exposure of 1 GOM DPS Atlantic sturgeon to the effects of the PIDP will not appreciably reduce the likelihood of survival of this species (i.e., it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of GOM DPS Atlantic sturgeon; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the GOM DPS of Atlantic sturgeon; (3) and, the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area (related to movements around the ensonified area) and no effect on the distribution of the species throughout its range.

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

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

New York Bight DPS
Individuals originating from the NYB DPS are likely to occur in the action area. The NYB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Delaware and Hudson rivers. Kahnle et al. (2007) estimated that there is a mean annual total mature adult population of 863 Hudson River Atlantic sturgeon. Using fishery-dependent data we have estimated that there are 87 Delaware River origin adults; combined, we estimate a total adult population of 950 in the New York Bight DPS. NYB DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the Hudson or Delaware River spawning populations or for the DPS as a whole.

NMFS has estimated that the proposed PIDP will result in injury to 19 or fewer Atlantic sturgeon, of which 17 are expected to be NYB DPS Atlantic sturgeon. The following analysis applies to anticipated effects on 17 individuals, but given the nature of the effects, it applies equally well to the worst case, but unlikely, scenario of all 19 being from the NYB DPS. The majority of individuals are likely to be Hudson River origin, but some may be Delaware River origin. No mortality is anticipated. Physiological effects are expected to be limited to minor injuries that will not impair the fitness of any individuals or affect survival. Behavioral responses are expected to be temporally and spatially limited to the area and time when underwater noise levels are greater than 150dB RMS and as such will be limited to only several hours at a time, and always less than 5 hours per day. The potential for behavioral responses is limited to the time when impact pile driving will take place and is therefore limited to a period of less than 5 hours for no more than 7 non-consecutive days during test pile installation and less than a minute during each of 7 days when redriving takes place. Behavioral responses could range from a temporary startle to avoidance of the ensonified area. We have determined that any behavioral responses, including in the worst case, complete avoidance of the ensonified area, would have insignificant and discountable effects to individuals. This is because while individuals may be displaced from, or avoid, the ensonified area: (1) there will always be at least 47% of the river width (an area 1.4 miles wide) with noise levels less than 150 dB re 1uPa RMS; (2) any changes in movements would be limited to a 5 hour period when pile driving would be occurring, for no more than 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place; (3) it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations; (4) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health, and, (5) any minor changes in behavior resulting from exposure to increased underwater noise associated with the PIDP will preclude any NYB DPS Atlantic sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. The survival of any NYB Atlantic sturgeon will not be affected by the proposed PIDP. As such, there will be no reduction in the numbers of NYB DPS Atlantic sturgeon and no change in the status of this species or its trend.

Reproductive potential of the NYB DPS is not expected to be affected in any way. As all sturgeon are anticipated to fully recover from any physiological impacts and any behavioral responses will not delay or disrupt any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, any delay in migration to the spawning grounds will be limited to several hours and is not anticipated to impact the success of reproduction. The proposed action will also not affect the spawning grounds within the Hudson River which is one of two rivers within the NYB DPS where spawning is thought to occur. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede NYB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporal and geographic scale of the area esonified by pile driving operations.

Based on the information provided above, the exposure of NYB DPS Atlantic sturgeon to the effects of the PIDP will not appreciably reduce the likelihood of survival of this species (i.e., it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of NYB DPS Atlantic sturgeon; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the NYB DPS of Atlantic sturgeon; (3) and, the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area (related to movements around the esonified area) and no effect on the distribution of the species throughout its range.

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

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

Chesapeake Bay DPS
Individuals originating from the CB DPS are likely to occur in the action area. The CB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the CB DPS, recent spawning has only been documented in the James River. Using fishery-dependent data, we have estimated that there are 329 adults in the James River population. Because the James River is the only river in this DPS known to support spawning, this is also an estimate of the total number of adults in the Chesapeake Bay DPS. Chesapeake Bay DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the James River spawning population or for the DPS as a whole.

NMFS has estimated that the proposed PIDP will result in injury to 19 or fewer Atlantic sturgeon of which 1 is expected to be a CB DPS Atlantic sturgeon. The following analysis applies to anticipated effects on 1 individual from the CB DPS, but given the nature of the effects, it applies equally well to the worst case, but unlikely, scenario of all 19 being from the CB DPS. No mortality is anticipated. Physiological effects are expected to be limited to minor injuries that will not impair the fitness of any individuals or affect survival. Behavioral responses are expected to be temporally and spatially limited to the area and time when underwater noise levels are greater than 150dB RMS and as such will be limited to only several hours at a time, and always less than 5 hours per day. The potential for behavioral responses is limited to the time when impact pile driving will take place and is therefore limited to a period of less than 5 hours for no more than 7 non-consecutive days during test pile installation and less than a minute during each of 7 days when redriving takes place. Behavioral responses could range from a temporary startle to avoidance of the ensonified area. We have determined that any behavioral responses, including in the worst case, complete avoidance of the ensonified area, would have insignificant and discountable effects to individuals. This is because while individuals may be displaced from, or avoid, the ensonified area: (1) there will always be at least 47% of the river width (an area 1.4 miles wide) with noise levels less than 150 dB re 1uPa RMS; (2) any changes in movements would be limited to a 5 hour period when pile driving would be occurring, for no more than 7 days in April and May 2012 and less than a minute during each of 7 days when redriving takes place; (3) it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations; (4) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health, and, (5) any minor changes in behavior resulting from exposure to increased underwater noise associated with the PIDP will preclude any Chesapeake Bay DPS Atlantic sturgeon from completing any essential behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. The survival of any shortnose sturgeon will not be affected by the proposed PIDP. As such, there will be no reduction in the numbers of CB DPS Atlantic sturgeon and no change in the status of this species or its trend.

Reproductive potential of the CB DPS is not expected to be affected in any way. As all sturgeon are anticipated to fully recover from any physiological impacts and any behavioral responses will not delay or disrupt any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, as the proposed action will occur outside of the rivers where CB DPS fish are expected to spawn (e.g., the James River in Virginia), the proposed action will not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution because the action will not impede CB DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporal and geographic scale of the area ensonified by pile driving operations.

Based on the information provided above, the exposure of CB DPS Atlantic sturgeon to the effects of the PIDP will not appreciably reduce the likelihood of survival of this species (i.e., it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of CB DPS Atlantic sturgeon; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the CB DPS of Atlantic sturgeon; (3) and, the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area (related to movements around the ensonified area) and no effect on the distribution of the species throughout its range.

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

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

CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of Atlantic sturgeon. No critical habitat is designated in the action area; therefore, none will be affected by the proposed action.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. 1538(g). See also 16 U.S.C. 1532(13)(definition of "person"). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement. The prohibitions against take for shortnose sturgeon are in effect now. The listing of Atlantic sturgeon is effective on April 6, 2012; therefore, the prohibitions on take are effective on this date and so are the exemptions provided by this ITS pertaining to Atlantic sturgeon.

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

Amount or Extent of Take

Pile driving carried out during the PIDP is expected to result in the injury of 19 or fewer shortnose sturgeon and 19 or fewer Atlantic sturgeon. All take is likely to be in the form of injury. As explained in the "Effects of the Action" section of the Opinion, none of these sturgeon are expected to die, immediately or later, as a result of exposure to increased underwater noise levels resulting from pile driving. All injuries are anticipated to be minor and any injured individuals are expected to make a full recovery with no impact to future survival or fitness. As explained in the "Effects of the Action" section, effects of the PIDP on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of ancillary piles by vibration, drilling to facilitate the installation of 1 pile, potential exposure to contaminants, a localized increase in vessel traffic, and effects to prey items. We have determined that all behavioral effects will be insignificant and discountable. We do not anticipate any take of shortnose sturgeon due to effects to prey items or due to exposure to contaminants or vessel traffic. This ITS exempts the following take:

- A total of no more than 19 shortnose sturgeon injured during the installation of the 7 test piles to be driven by an impact hammer; and,
- A total of no more than 19 Atlantic sturgeon injured during the installation of the 7 test piles to be driven by an impact hammer. Based on mixed stock analyses, we anticipate that no more than 1 of the Atlantic sturgeon will be GOM DPS origin and no more than 1 will be Chesapeake Bay DPS origin. The remaining 17 Atlantic sturgeon will be New York Bight DPS origin.

No lethal take is anticipated. In the accompanying Opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to shortnose sturgeon or to any DPS of Atlantic sturgeon.

While we have been able to estimate the likely number of shortnose and Atlantic sturgeon to be taken as a result of the PIDP, it may be impossible to observe all sturgeon affected by the pile installation. This is because both shortnose and Atlantic sturgeon are aquatic species who spend the majority of their time near the bottom, making it very difficult to monitor movements of individual sturgeon in the action area to document changes in behavior or to capture all affected individuals to document injuries. Because of this, the likelihood of discovering take attributable to this proposed action is very limited. There is no practical way to monitor the entire ensonified area during test pile installations to document the number of sturgeon exposed to underwater noise. We considered several methods to monitor the validity of our estimates that there will be 19 or fewer shortnose and 19 or fewer Atlantic sturgeon exposed to underwater noise that would result in injury. We considered requiring monitoring for sturgeon with gillnets or trawls within the ensonified area; however, because we expect the pile driving noise to cause sturgeon to leave the area, this method would not likely provide us with relevant information regarding the number of sturgeon affected. We also considered requiring surveys outside of the ensonfied area; however, this would possibly intercept sturgeon that were displaced from the ensonified area as well as fish that were present in the area being sampled, but not because of displacement. Thus, using this approach, it would be difficult to determine anything meaningful about the number of sturgeon affected by the PIDP. In addition, gillnets may be very effective at catching sturgeon; however, we chose a method of monitoring take that would not exacerbate adverse effects. Sturgeon captured in trawls generally have a lower mortality rate than those captured in gillnets, however, there may be added stress upon capture. The fish, particularly larger fish, may also be able to avoid a trawl. We also considered whether monitoring of tagged sturgeon would allow us to monitor take. However, because we do not know what percentage of sturgeon in the action area are likely to be tagged, it is not possible to determine the total number of sturgeon affected by the action based on the number of tagged sturgeon detected in the area. Further, if no tagged sturgeon were detected, we could not use that information to determine that no sturgeon were affected because it may just mean that there were no tagged sturgeon in the area.

Because we have dismissed all of these monitoring methods as neither reasonable nor appropriate, we will use a means other than counting individuals to assess the level of take. In situations where we cannot observe the actual individuals affected, the proxy must be rationally connected to the taking and provide an obvious threshold of exempted take which, if exceeded, provides a basis for reinitiating consultation. For this proposed action, the spatial and temporal extent of the area where underwater noise levels will be greater than 206 dB re 1uPa peak and the area where underwater noise levels will be greater than 187 re 1 μPa^2-s cSEL provides a proxy for estimating the actual amount of incidental take. We expect that this proxy will be the primary method of determining whether incidental take has been exceeded, given the potential that stunned or injured fish will not be observed. However, in order to increase the chances of detecting when incidental take has been exceeded, we have identified other methods as well. We will consider incidental take exceeded if any of the following conditions are met:

i) For any of the 7 test piles being installed with an impact hammer:

    (a) The geographic extent of the area where noise is greater than 206 dB re 1 uPa peak is greater than the area considered in the "Effects of the Action" section of this Opinion, which is related to the area used to calculate the number of takes anticipated.

    (b) The duration of time that noise is greater than 206 dB re 1 uPa peak is greater than the amount of time considered in the "Effects of the Action" section of this Opinion, which is related to the amount of time used to calculate the number of takes anticipated.

(c) The geographic extent of the area where noise is greater than 187 dB re 1 μPa^2-s is cSEL greater than the area considered in the “Effects of the Action” section of this Opinion, which is the area used to calculate the number of takes anticipated.

(d) The duration of time that noise is greater than 187 re 1 μPa^2-s cSEL is greater than the amount of time considered in the “Effects of the Action” section of this Opinion, which is the amount of time used to calculate the number of takes anticipated.

ii) More than 19 shortnose sturgeon are observed stunned or injured.

iii) Any dead shortnose or Atlantic sturgeon are observed.

iv) More than 17 New York Bight DPS, 1 Chesapeake Bay DPS, and 1 Gulf of Maine DPS Atlantic sturgeon are observed stunned or injured.

Method (iv) above would depend on the ability to obtain a fin clip for genetic testing and assignment of the fish to one of the DPSs. It is possible, but unlikely, that genetic test results could be obtained in time to reinitiate consultation prior to completion of the PIDP. It is also possible that the genetic results would not be available in the near term. However, even if the genetic results are not obtained prior to completion of the PIDP, this method would yield important information regarding whether incidental take was exceeded and that information could be factored into analyses for future consultations. The possibility that genetic test results will not be available in the near term is one reason why we have chosen to use a number of different methods to monitor incidental take.

Reasonable and Prudent Measures

In order to effectively monitor the effects of this action, it is necessary to monitor the impacts of the proposed action to document the amount of incidental take (i.e., the number of shortnose sturgeon captured, collected, injured or killed) and to examine any sturgeon that are captured during this monitoring. Monitoring provides information on the characteristics of the sturgeon encountered and may provide data which will help develop more effective measures to avoid future interactions with listed species. We do not anticipate any additional injury or mortality to be caused by removing the fish from the water and examining them as required in the RPMs. Any live sturgeon are to be released back into the river, away from the pile driving activities.

NMFS believes the following reasonable and prudent measures are necessary or appropriate for FHWA to minimize and monitor impacts of incidental take of listed shortnose and Atlantic sturgeon:

1. FHWA must implement a program to monitor underwater noise resulting from the installation of piles during pile installation operations associated with the PIDP.

2. FHWA must implement a program to monitor impacts to sturgeon resulting from pile installation must be implemented throughout the duration of pile driving operations associated with the PIDP.

3. All live sturgeon captured during monitoring must be released back into the Hudson River at an appropriate location away from the pile driving activity that minimizes the additional risk of death or injury.

4. Any dead sturgeon must be transferred to NMFS or an appropriately permitted research facility NMFS will identify so that a necropsy can be undertaken to attempt to determine the cause of death.

5. All sturgeon captures, injuries or mortalities associated with the PIDP and any sturgeon sightings in the action area must be reported to NMFS.

Terms and Conditions
In order to be exempt from prohibitions of section 9 of the ESA, FHWA must comply with the following terms and conditions of the Incidental Take Statement, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Any taking that is in compliance with the terms and conditions specified in this Incidental Take Statement shall not be considered a prohibited taking of the species concerned (ESA Section 7(o)(2)).

1. To implement RPM #1, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with driving the test piles with impact hammers. The monitoring program must be sufficient to establish the peak sound level and distance from the pile to this sound level, the cumulative sound exposure level and the distance at which sound will be greater than 187 dB re 1 μPa^2-s cSEL and 150 dB re 1 µPa RMS. The monitoring program must also document the duration (i.e., minutes/hours) of time it takes to install each pile and the duration of time the area is ensonified.
2. To implement RPM #1, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with drilling rock to install the rock socket for installation of the 8 ft. diameter pile. The monitoring program must be sufficient to establish the peak sound level and the cSEL during drilling.
3. To implement RPM#1, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with installing ancillary piles with a vibratory method. The monitoring program must be sufficient to establish the peak sound level and the cSEL.
4. To implement RPM#1, FHWA must report results from the sound monitoring to NMFS as soon as practicable. If there is any indication that peak noise levels have exceeded 206 dB re 1 µPa peak or 187 dB re 1 μPa^2-s cSEL for longer than anticipated or over a greater geographic area than anticipated (see Table 7 and Table 10 in the Opinion), NMFS must be contacted immediately.

5. To implement RPM #1, "Short range" results (monitored within 10 meters of the pile), must be reported to NMFS daily. "Long range" results (monitored outside of 10 meters) must be reported to NMFS within 7 days. A draft report must be transmitted to NMFS within 30 days of the completion of pile installation.

6. To implement RPM#2, FHWA must ensure acoustic telemetry equipment is utilized to monitor for the presence, residence time and movement of tagged Atlantic and shortnose sturgeon in the project area. FHWA must design a monitoring plan that would ensure the detection of any acoustically tagged shortnose or Atlantic sturgeon in the action area. This monitoring plan must be approved by NMFS prior to the installation of the first test pile. FHWA must ensure all occurrences of tagged sturgeon in the project area are recorded. Information collected from any stationary receivers must be downloaded within 24 hours of completion of each test pile installation. Preliminary results must be provided to NMFS as soon as possible. If active tracking is utilized, FHWA must provide NMFS with information on sturgeon detections within 24 hours of the completion of the installation of each test pile. FHWA must provide NMFS with a preliminary report summarizing all available information from the monitoring equipment on sturgeon detections and movements within 15 days of the completion of pile installation and a final report within 30 days of completion of pile installation. This term and condition does not require FHWA to tag any sturgeon with telemetry tags.

7. To implement RPM#2, FHWA must ensure the project area is monitored for the presence of any floating dead or injured sturgeon. FHWA must design a monitoring plan that would ensure the detection of any floating stunned, injured or dead sturgeon. We anticipate that this would be accomplished by using at least one small boat to run transects through the project area during and after the installation of piles installed with impact hammers and at least one monitor on the barge next to the pile being driven with radio communication to the boat. The location of the transects must take tidal currents into consideration. This plan must be approved by NMFS prior to the installation of any of the 7 test piles.

8. To implement RPM#3, FHWA must ensure any observed live sturgeon are collected with a net and are visually inspected for injuries. Collected fish must be held on board a vessel with a flow through live well. All collected fish must be inspected for a PIT tag with an appropriate PIT tag reader. Injured fish must be visually assessed, measured, photographed, released away from the site and reported to NMFS. The reporting form included as Appendix A must be filled out and transmitted to NMFS using the procedures outlined below.

9. To implement RPM #3, FHWA must ensure that fin clips are taken (according to the procedure outlined in Appendix B) of any sturgeon captured during the PIDP and that the fin clips are sent to NMFS for genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies.

10. To implement RPM#4, FHWA must ensure that any observed dead sturgeon are collected with a net, reported to NMFS, preserved as appropriate to allow for necropsy, and that NMFS is contacted immediately to discuss necropsy and other procedures. NMFS may request that the specimen be transferred to NMFS or to an appropriately permitted

researcher approved by NMFS so that a necropsy may be conducted. The form included as Appendix A must be completed and submitted to NMFS as noted above.

11. To implement RPM #5, if any live or dead sturgeon are observed or captured during monitoring, FHWA must ensure that NMFS (978-281-9328) is notified immediately and that an incident report (Appendix A) is completed by the observer and sent to the NMFS Section 7 Coordinator via FAX (978-281-9394) or e-mail (incidental.take@noaa.gov) within 24 hours of the take. FHWA must also ensure that every sturgeon is photographed. Information in Appendix C will assist in identification of shortnose and Atlantic sturgeon.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed action. Specifically, these RPMs and Terms and Conditions will ensure that FHWA monitors the acoustic impacts of the PIDP and effects to shortnose and Atlantic sturgeon in a way that allows for the detection of any injured or killed sturgeon and to report all interactions to NMFS and to provide information on the likely cause of death of any shortnose and Atlantic sturgeon captured during the PIDP. The discussion below explains why each of these RPMs and Terms and Conditions are necessary or appropriate to minimize or monitor the level of incidental take associated with the proposed action. The RPMs and terms and conditions involve only a minor change to the proposed action.

RPM #1 and #2 and Term and Condition #1-6 are necessary and appropriate because they are specifically designed to monitor underwater noise associated with the pile driving. Because our calculation of take is tied to the geographic area where increased underwater noise will be experienced, it is critical that acoustic monitoring take place to allow FHWA to fulfill the requirement to monitor the actual level of incidental take associated with the PIDP and to allow NMFS and FHWA to determine if the level of incidental take is ever exceeded. Monitoring with acoustic receivers will detect the presence and movements of tagged sturgeon in the action area and should also provide us with information on residence times and movements within the action area. We expect this data will provide important information on the behavioral responses of tagged sturgeon to the pile driving activities.

RPM#3 and Term and Condition #7-9 are necessary and appropriate to maximize the potential for detection of any affected sturgeon. These measures will ensure that any sturgeon that are observed injured are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality by being further subject to increased underwater noise. The taking of fin clips allows NMFS to run genetic analysis to determine the DPS of origin for Atlantic sturgeon. This allows us to determine if the actual level of take has been exceeded. Sampling of fin tissue is used for genetic sampling. This procedure does not harm sturgeon and is common practice in fisheries science. Tissue sampling does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact. NMFS has received no reports of injury or mortality to any sturgeon sampled in this way.

RPM #4 and Terms and Conditions #10 and are necessary and appropriate to ensure the proper handling and documentation of any sturgeon removed from the water that are dead or die while in FHWA custody. This is essential for monitoring the level of incidental take associated with the proposed action and in determining whether the death was related to the PIDP.

RPM#5 and Term and Condition #11 are necessary and appropriate to ensure the proper handling and documentation of any interactions with listed species as well as the prompt reporting of these interactions to NMFS.

CONSERVATION RECOMMENDATIONS

In addition to Section 7(a)(2), which requires agencies to ensure that all projects will not jeopardize the continued existence of listed species, Section 7(a)(1) of the ESA places a responsibility on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species." Conservation Recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. As such, NMFS recommends that the FHWA consider the following Conservation Recommendations:

1. The FHWA should use its authorities to ensure tissue analysis of dead sturgeon removed from the Hudson River during the course of the PIDP is performed to determine contaminant loads.
2. The FHWA should use its authorities to support studies on shortnose and Atlantic population status and distribution of individuals in the Hudson River. Such studies could involve site specific surveying or monitoring, targeted at the collection of these species, in the months prior to any bridge replacement or other project, aimed at further documenting seasonal presence in the action area and further documenting the extent that individuals use different parts of the action area (i.e., the deepwater channel vs. shallower areas near the shoreline).

REINITIATION OF CONSULTATION

This concludes formal consultation on the Tappan Zee PIDP. 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 taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately.

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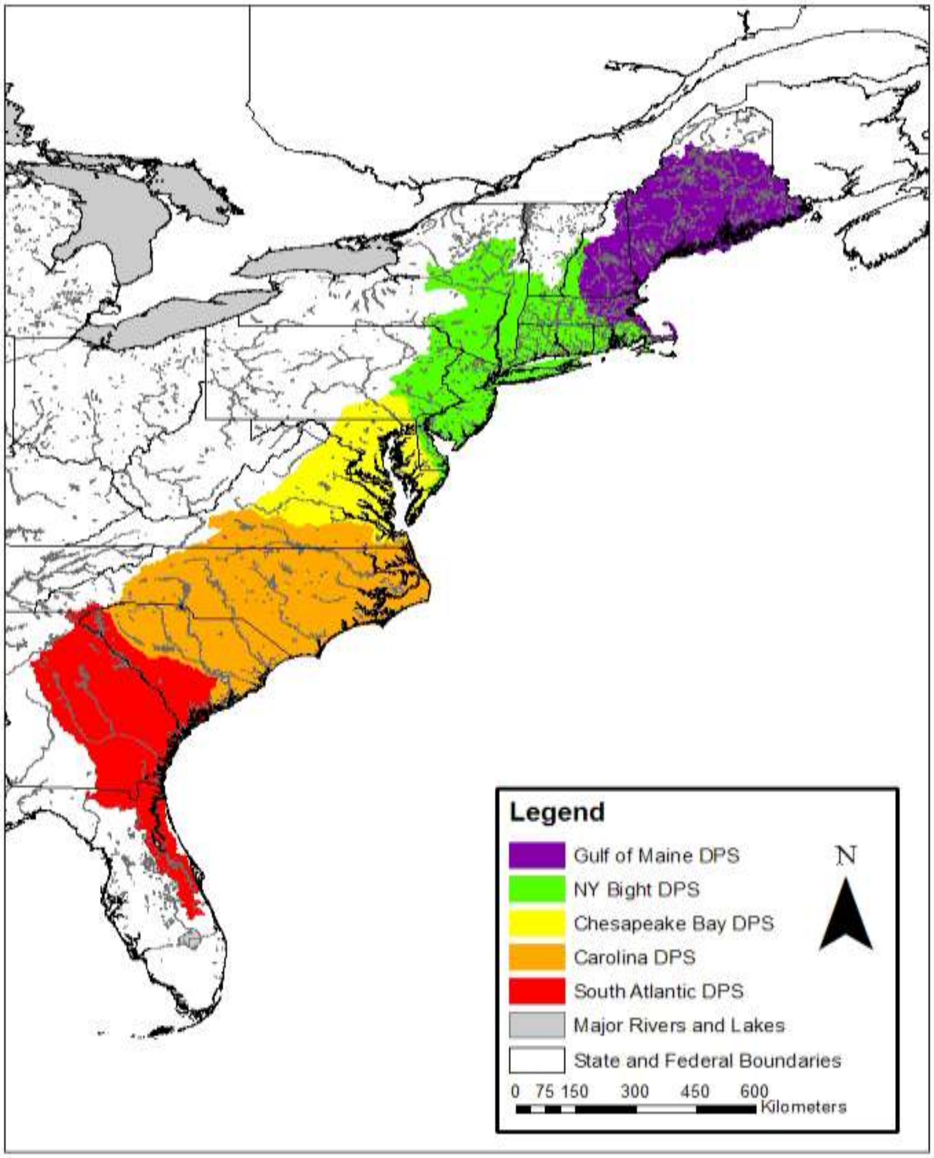
Figure 2

Figure 3 – Map depicting the boundaries of 5 Atlantic sturgeon DPSs.



Appendix A

Incident Report: Sturgeon Take – Tappan Zee PIDP

Photographs should be taken and the following information should be collected from all sturgeon (alive and dead) found in association with the PIDP. Please submit all necropsy results (including sex and stomach contents) to NMFS upon receipt.

Observer's full name:____
Reporter's full name:____

Species Identification:____

Describe Pile Driving Activities ongoing within 24 hours of observation:____
____

Date animal observed:________________ Time animal observed: ________________________
Date animal collected:________________ Time animal collected:_________________________

Environmental conditions at time of observation (i.e., tidal stage, weather):
____
____

Water temperature (°C) at site and time of observation:_________________________
Describe location of fish and how it was documented (i.e., observer on boat):
____

Sturgeon Information:
Species ____________________________________

Fork length (or total length) _______________________ Weight ________________________

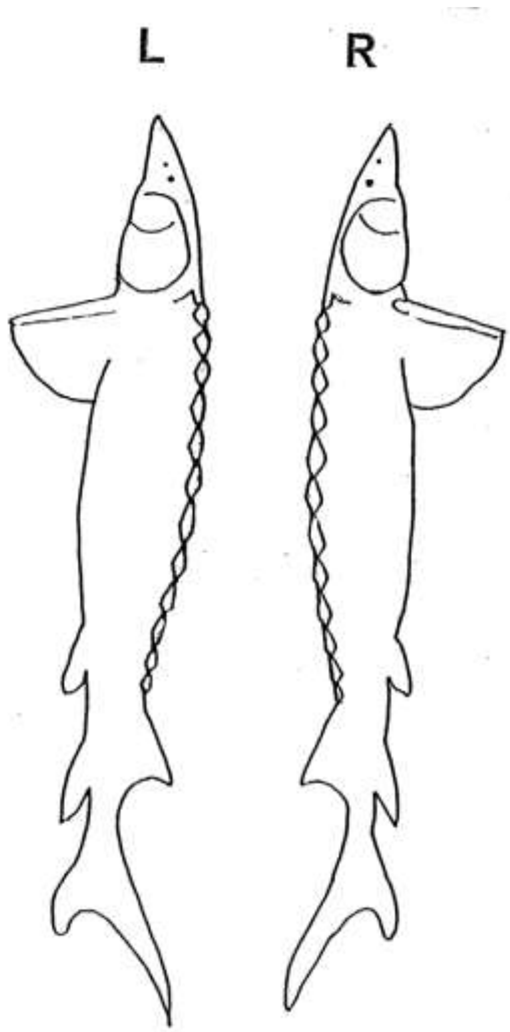
Condition of specimen/description of animal
____
____
____
____

Fish Decomposed: NO SLIGHTLY MODERATELY SEVERELY
Fish tagged: YES / NO *Please record all tag numbers.* Tag # _________________

Photograph attached: YES / NO
(please label *species, date, geographic site* and *vessel name* on back of photograph)

Appendix A, continued

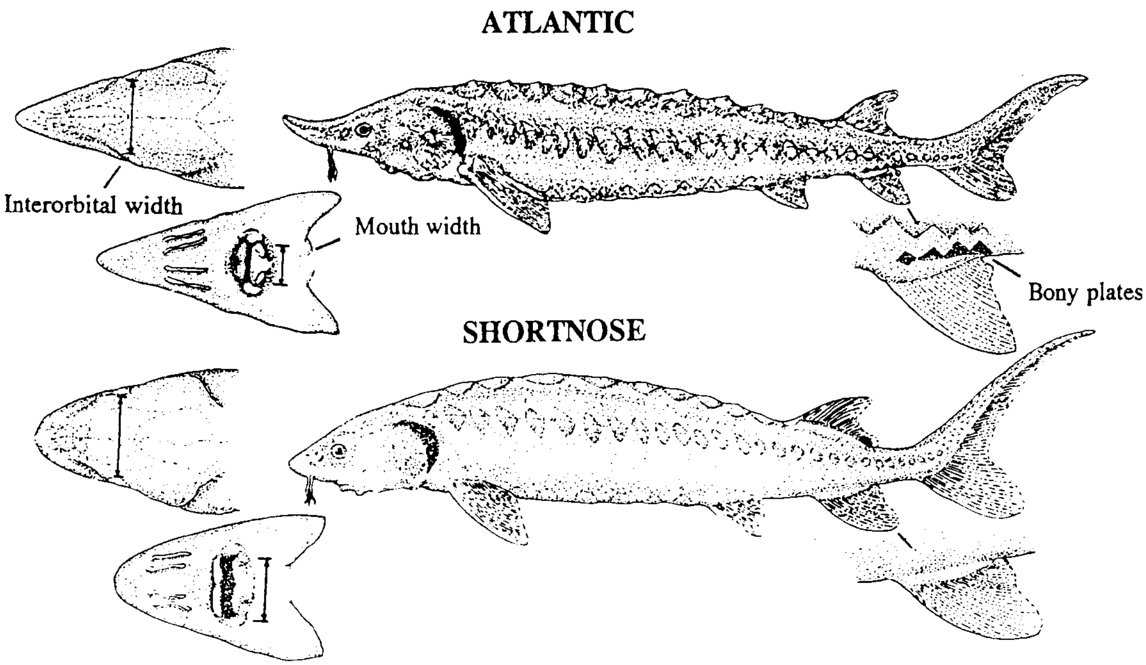
Draw wounds, abnormalities, tag locations on diagram and briefly describe below



Description of fish condition:

Appendix C

Identification Key for Sturgeon Found in Northeast U.S. Waters



Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

Characteristic	**Atlantic Sturgeon, *Acipenser oxyrinchus***	**Shortnose Sturgeon, *Acipenser brevirostrum***
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004

APPENDIX B

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

1. Wash hands and use disposable gloves. Ensure that any knife, scalpel or scissors used for sampling has been thoroughly cleaned and wiped with alcohol to minimize the risk of contamination.

2. For any sturgeon, after the specimen has been measured and photographed, take a one-cm square clip from the pelvic fin.

3. Each fin clip should be placed into a vial of 95% non-denatured ethanol and the vial should be labeled with the species name, date, name of project and the fork length and total length of the fish along with a note identifying the fish to the appropriate observer report. All vials should be sealed with a lid and further secured with tape Please use permanent marker and cover any markings with tape to minimize the chance of smearing or erasure.

Storage of Sample

1. If possible, place the vial on ice for the first 24 hours. If ice is not available, please refrigerate the vial. Send as soon as possible as instructed below.

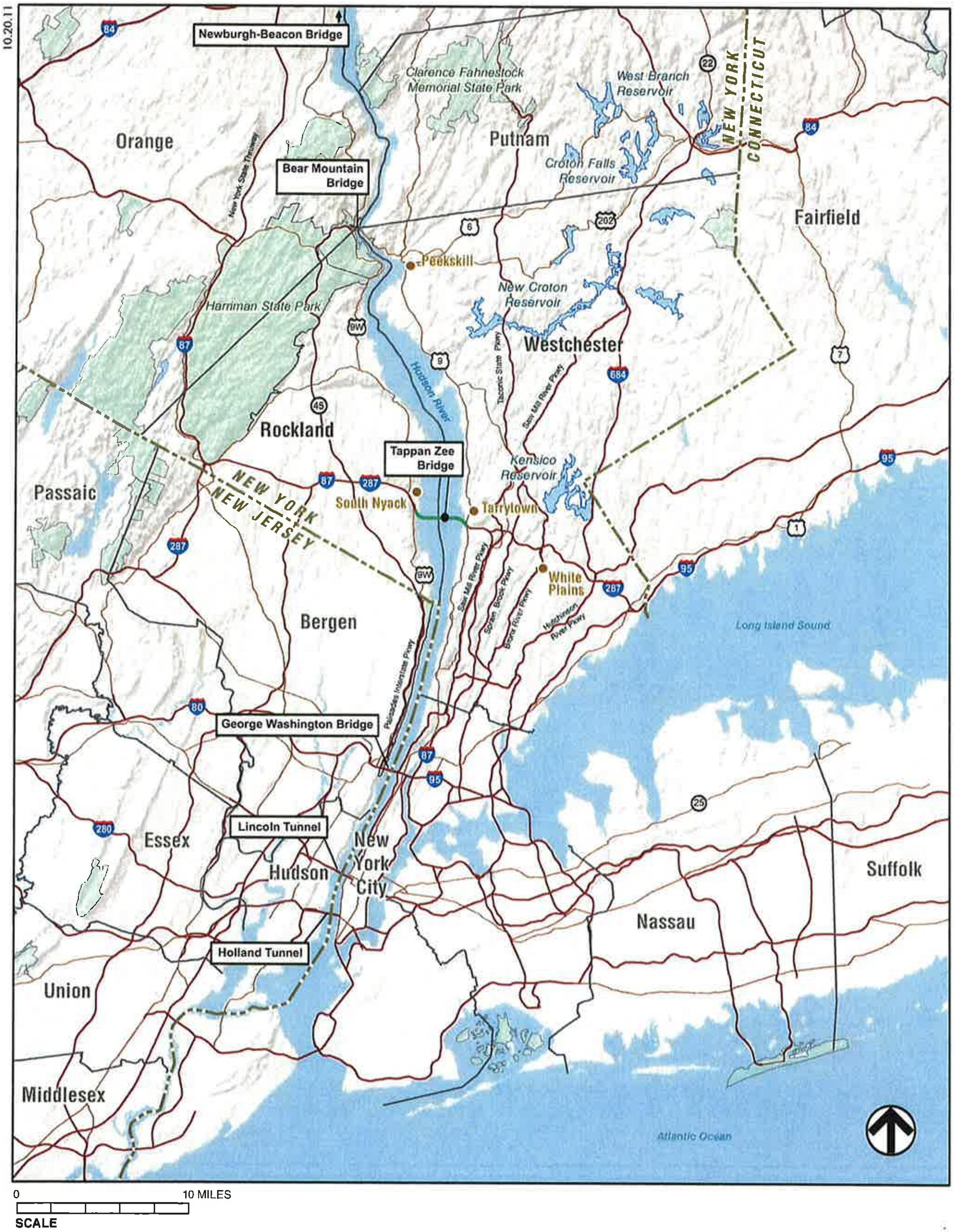
Sending of Sample

1. Vials should be placed into Ziploc or similar resealable plastic bags. Vials should be then wrapped in bubble wrap or newspaper (to prevent breakage) and sent to:

   Julie Carter
   NOAA/NOS – Marine Forensics
   219 Fort Johnson Road
   Charleston, SC 29412-9110
   Phone: 843-762-8547

   a. Prior to sending the sample, contact Russ Bohl at NMFS Northeast Regional Office (978-282-8493) to report that a sample is being sent and to discuss proper shipping procedures.

10.20.11



From
TAPPAN ZEE HUDSON RIVER CROSSING
Environmental Impact Statement

Project Location