**ENDANGERED SPECIES ACT SECTION 7 CONSULTATION**
**BIOLOGICAL OPINION**

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| **Agency:** | Federal Highway Administration, New York Division (lead)<br>Army Corps of Engineers, New York District<br>U.S. Coast Guard |
| **Activity:** | **Tappan Zee Bridge Replacement**<br>**NER-2013-10768** |
| **Conducted by:** | NOAA's National Marine Fisheries Service<br>Northeast Regional Office |
| **Date Issued:** | 4/2/14 |
| **Approved by:** | [signature] for John Bullard |

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## 1.0 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 Replacement Project. The U.S. Federal Highway Administration (FHWA) is the lead agency for the proposed bridge replacement. The U.S. Army Corps of Engineers (USACE) is proposing to authorize components of the bridge replacement under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. The U.S. Coast Guard (USCG) will authorize the bridge replacement under the General Bridge Act of 1946.

This Opinion replaces an Opinion we issued on June 29, 2012. We are basing this Opinion on information provided in a Biological Assessment (BA) dated January 2012, a revised BA dated April 2012, a Final Environmental Impact Statement (FEIS) dated August 2012, results of the Pile Installation Demonstration Project (PIDP) provided to us throughout 2012, a revised project description and supplemental assessment dated February 2013 and transmitted to us on February 25, 2013, and other sources of available information as cited in this Opinion. We will keep a complete administrative record of this consultation on file at our Northeast Regional Office, Gloucester, Massachusetts.

## 2.0 BACKGROUND AND CONSULTATION HISTORY

We began coordination with FHWA, the New York Department of Transportation (NYSDOT), the New York State Thruway Authority (NYSTA), and their project team in 2006 regarding the potential replacement of the Tappan Zee Bridge.

In 2006, we worked with the project team on their design of a gillnet sampling study that was undertaken near the bridge site. Work occurred under an Incidental Take Permit issued by NMFS Office of Protected Resources under section 10(a)1(A) of the ESA. Data was collected from April 2007 through May 2008 with additional sampling of oyster beds and submerged aquatic vegetation (SAV) during 2009. We participated in several meetings with FHWA and their project team beginning in 2008.

Beginning in October 2011, we worked with FHWA and the project team regarding the planned PIDP. We completed section 7 consultation on the effects of the PIDP on shortnose sturgeon and three Distinct Population Segments (DPS) of Atlantic sturgeon. This consultation was completed with the issuance of a Biological Opinion on March 7, 2012. The Opinion concluded that the PIDP was likely to adversely affect, but not likely to jeopardize the continued existence of these species.

We have also reviewed and provided comments on a Preliminary PDEIS and the January 2012 DEIS. A meeting was held on December 14, 2011, to continue the coordination of the PIDP and the Project's Biological Assessment and Essential Fish Habitat analyses.

FHWA submitted a BA to us along with a request to initiate section 7 consultation on January 27, 2012. A revised BA was submitted on April 13, 2012; that served as the initiation date for this consultation. FHWA submitted results of the PIDP to us through May 2012. Information supplementing the April BA was submitted on May 31, 2012.

We issued a final Biological Opinion to FHWA on June 21, 2012. In this Opinion, we considered the effects of two bridge replacement alternatives, a short span and a long span option; both alternatives would have required installation of [redacted] piles. The consultation also considered effects of dredging, river armoring, and disposal of dredged material at the Historic Area Remediation Site (HARS).

In December 2012, NYSTA selected a Design-Build contractor. Information on the selected bridge design was presented to us at a January 28, 2013 meeting. The final design is different from both alternatives considered in our 2012 Opinion. It will involve less dredging, smaller impacts to oyster beds and will eliminate the use of [redacted] piles. Additionally, the dredged material disposal site has changed and a supplemental Pile Installation Demonstration Project (PIDP or pile load testing) is proposed.

Reinitiation of consultation is required when the action agency still has discretion over the project and 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 the Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. FHWA retains discretion over the project because the final authorizations to proceed have not been provided; therefore, FHWA is not precluded from changing measures to benefit listed species. FHWA and NMFS have agreed that reinitiation of consultation is necessary because of the changes to the proposed action that may cause effects not considered in the 2012 Opinion. Consultation was reinitiated on February 25, 2013 and a final Opinion was issued on April 9, 2013.

During the Fall of 2013, FHWA notified us that the project team was considering changes to project construction. FHWA requested reinitiation of consultation in a letter dated November 8, 2013. Reinitiation is necessary to consider modifications of the proposed action which will have effects to listed species not considered in the 2013 Opinion. Specific changes, detailed in the Description of the Action section below include: the use of bed levelers following dredging, modifications to the number and size of piles for the bridge and modifications to the installation methods for piles supporting the work trestles on the Westchester and Rockland shorelines. FHWA provided an assessment of the effects of these activities on listed species on November 8, 2013. Supplemental information was provided by FHWA on December 6, 2013. On March 6, 2014, FHWA provided an update to the project schedule that reflected changes to the dates when piles would be installed. These changes were necessitated by harsh winter weather conditions which resulted in delays to pile installation. We completed formal consultation with the issuance of a Biological Opinion on March 12, 2014.

The March 12 Opinion was provided to FHWA on March 13, 2014. On March 14, 2014, FHWA informed us that several errors were present in the March 12 Opinion. Most significantly, these included erroneous tables and figures as well as a miscalculation of the amount of take that had occurred to date. NMFS and FHWA determined that reinitiation was necessary to replace the March 12 Opinion. Consultation was reinitiated on March 21, 2014.

## 3.0 DESCRIPTION OF THE PROPOSED ACTION

### 3.1 Federal Actions

FHWA is providing funds for the bridge replacement project and the USCG has issued a permit under the General Bridge Act of 1946 for construction of the replacement bridge. The USACE, New York District is permitting in-water work associated with the project under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. NYSTA and its contractors will design and construct the project. FHWA is the lead federal agency for the project for purposes of this ESA consultation and coordination under the National Environmental Policy Act (NEPA).

### 3.2 Summary of Proposed Action

The proposed project will result in a new bridge crossing of the Hudson River between Rockland and Westchester Counties and the demolition of the existing Tappan Zee Bridge. The replacement bridge will be constructed north of the existing Tappan Zee Bridge. To conform to highway design standards, including widths and grades, there will also be modifications to Interstate 87/287 between approximately South Broadway in Nyack and Interchange 9 (Route 9) in Tarrytown. [redacted]

The landings will tie in the new geometry of the proposed bridge with the geometry of the existing roadway. The landings would employ typical highway construction techniques and would be completed on both the Westchester and Rockland sides of the Hudson River upland from the bridge abutments. Construction of the landings would occur throughout the duration of the project. The construction activity for the landings would be staged, as the roadways on both sides would be altered and then maintained before being altered again. The alterations to the landings would consist of changes in roadway grade, elevation, direction, and general configuration.

From the abutments, the new bridge approach spans will carry traffic from land to the main span of the bridge. Construction of the approach spans would last for approximately two and a half to three years. The piles, pile caps, piers, and deck that comprise the approach spans of the bridge will be built sequentially so that as a new bent of piles is being driven, a new pile cap would be installed on a completed bent of piles. In-water work associated with building the approach spans involves pile and cofferdam installation.

The main span would stretch between the Westchester and Rockland approach spans across the federal navigation channel. This segment of the bridge would be defined largely by its superstructure design as a cable stayed bridge. Within its substructure, the piers would be more substantial than those of the approaches. All main span work would be done sequentially and in a similar manner to the approaches. The piles, pile caps, pylons, and deck construction would last approximately three and a half years.

Substructure construction would establish the foundation of the bridge through the processes of pile driving, construction of pile caps, and construction of columns. Superstructure construction would then take place from barge-based cranes, which will be used to place pre-assembled bridge spans.

Construction will require a wide range of activities on both land and temporary work trestles, as well as from barges within the river. In addition, due to the lack of available land along the waterfront near the bridge, staging areas at some distance from the construction site would be required. Some bridge components would be pre-fabricated and transported to the site via barge.

To support construction of the main span and approach spans, miscellaneous materials, equipment, and crews will be transported from upland staging areas in Westchester and Rockland counties to work trestles that will be constructed on the shoreline of the river, as shown in Figure 2. In-water construction work will also be supported by vessels (barges, tug boats, etc.). Due to the anticipated draft requirements of the work vessels, dredged channels will be required to provide access to work areas in shallow portions of the proposed construction zone within the rive [redacted].

### 3.3 Required Environmental Performance Commitments

FHWA will require that certain Environmental Performance Commitments (EPCs) be employed during construction of the substructure.

- Using cofferdams, silt curtains or other methods, where feasible, to minimize discharge of sediment into the river.
- Using a vibratory pile driver, to the extent feasible, particularly for the initial pile segment.
- Limiting the periods of pile driving to no more than 12-hours/day except in rare circumstances, when safety or other constraints require completion of work begun that day.
- Using bubble curtains, cofferdams, or other technologies to achieve a reduction of at least 10dB of noise attenuation for production piles [redacted]
- Maintaining a corridor where the sound level is below a $SEL_{cum}$ of 187 dB re $1uPa^2{\cdot}s$ [redacted] at all times during impact hammer pile driving. This corridor shall be continuous to the maximum extent possible [redacted]. The location of the acoustic corridor can vary.
- Pile tapping (i.e. a series of minimal energy strikes) for an initial period to cause fish to move from the immediate area.
- Continuing to implement a comprehensive monitoring plan as described in the Dredging and Pile Driving Monitoring Plan. Elements include:
    - Monitoring water quality parameters in accordance with the Water Quality Monitoring Plan s in the vicinity of the pile driving;
    - Monitoring fish mortality and inspection of fish for types of injury, as well as a program for determining contaminant levels in dead sturgeon through tissue analysis methods, as feasible;
    - Monitoring the recovery of the benthic community within the dredged area at the end of the construction period;
    - Supporting the Atlantic and shortnose sturgeon sonic tagging program through coordination with NMFS and NYSDEC. This may include placement of telemetry receivers in the project area;
    - Monitoring predation levels by gulls and other piscivorous birds, which would indicate an increased number of dead or dying fish at the surface; and,
    - Preparing appropriate plans outlining the monitoring and reporting methods to be implemented during the program.

- In addition, access channel dredging (using a clamshell dredge with an environmental bucket and no barge overflow) would only be conducted during a three-month period from August 1 to November 1, for the two years of the construction period in which dredging would occur. This time of year restriction is designed to minimize the potential for interaction with the dredge and migration effects to sturgeon and other fish species.
- Armoring of the channel to prevent re-suspension of sediment during the movement of construction vessels.

FHWA is note requiring noise attenuation for impact pile driving of [redacted] piles installed to support work trestles and bridge piers. This is due to the short duration of impact pile driving (less than 10 minutes for trestle piles and less than 20 minutes for [redacted] bridge piles) and the small isopleth size for the 206 dB peak sound pressure level [redacted]. Together, these factors minimize the spatial and temporal extent of underwater noise such that the effects of noise attenuation are minimal.

## 3.4 Construction of the new bridge

Project construction would take approximately 5 years; construction began in the summer 2013. This schedule includes both preliminary activities to support the construction of the project (i.e., geotechnical investigation, pile load testing, dredging and landings) as well as individual elements of bridge construction (i.e., main span and approaches). Throughout the construction period, roadway work would be required at various times. During that time, the approach roadways would be shifted and remain in the new location before being shifted again. Dredging would occur in two stages between August 1 and November 1 over the first two years of construction; the first stage of dredging was completed in 2013. Construction of the main span would consist of approximately 4 years of construction. Demolition of the existing Tappan Zee Bridge would be expected to take approximately 1½ years.

### *3.4.1 Waterfront Construction Staging*

Temporary platforms will facilitate construction in shallow water areas adjacent to the shoreline. A permanent platform along the Rockland County side would be extended out from the shoreline over the Hudson River (see Figure 2) to enable the continued maintenance of the original Tappan Zee Bridge as well as providing continued support for the NYSTA Dockside Maintenance facility operation. These platforms would provide access to the replacement bridge site. Upon completion of construction, the temporary platforms and the piles that support them would be removed.

Two temporary trestles, Westchester and Rockland, are being installed to facilitate construction of the bridge. The Westchester temporary trestle, when completed, will have [redacted] piles. The North and South Rockland trestles and permanent platform, when completed, will have [redacted] [redacted] piles, of which [redacted] are for the permanent platform, [redacted] are for the temporary north trestle and [redacted] are for the temporary south trestle. All of these [redacted] piles will be installed primarily with a vibratory hammer, but a low energy (<100,000 foot-pounds) impact hammer is required for final seating. The impact hammer will be used for 5-10 minutes for each pile.

The piles for the Westchester trestle and finger piers are approximately 74% complete [redacted] as of January 17, 2014. The piles for the Rockland trestle are approximately 42% complete [redacted] as of January 17, 2014.

### *3.4.2 Dredged Access Channel*

Since the proposed bridge alignment spans extensive shallows, FHWA has determined it is necessary to dredge an access channel for tugboats and barges to utilize during construction of the approach spans. These vessels will be used for pile driving, the construction of pile caps and bridge piers, and the erection of bridge decks and other superstructure components.

As shown in Figure 3, dredging would be conducted in two stages between August 1 and November 1 over a 2-year period. An environmental bucket dredge will be used with no barge overflow allowed. The purpose of the first dredging stage (2013) would be to provide access for bridge construction along both approaches and to the north of the existing Tappan Zee Bridge, while the second dredging stage (2014) would provide access for demolition of portions of the existing bridge, allowing for completion of the remaining portions of the new structure.

Based on an analysis of the types, number, size and operation of vessels that would operate in the access channel during construction, it was determined that a clear draft [redacted] would be required within the access channel at the lowest observed water level, which occurs during the Spring Neap Tide. The lowest observed water level is referred to as Mean Lower Low Water (MLLW).

Table 1 shows the amount of material to be dredged during each stage. [redacted] It is estimated that [redacted] sediment would be removed from the river bottom.

**Table 1.** Volume of dredged material to be removed by stage

| Construction Stage | Dredging Quantity | |
|---|---|---|
| | [redacted] | Percent of Total |
| Stage 1 | [redacted] | 84% |
| Stage 2 | [redacted] | 16% |
| Total | [redacted] | 100% |

### *3.4.3 Armoring of River Bottom in Dredged Access Channel*

To minimize re-suspension of fine sediment material due to movement of vessels, particularly tugboats, within the dredged channel, a layer of sand or gravel (referred to as “armor”) would be placed at the bottom of the channel following dredging. FHWA determined the sediments in the vicinity of the area to be dredged are highly susceptible to resuspension into the water column. Without “armoring,” prop scour from working tugboats in the channel would result in the generation of suspended sediment at rates several orders of magnitude greater than what would occur from the dredging operation itself.

The installation of the sand and gravel would take place as soon as the dredging for that section of the channel was successfully completed, forming a protective layer to keep sediment from further disturbance. The sand and gravel materials would be delivered by barges or scows, and would be placed within the channel by barge-mounted cranes. The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. The dredging depth required assumes that [redacted] sand and gravel armor is placed on the bottom. In total, the channel would be dredged to a depth corresponding [redacted] below MLLW [redacted] to allow for the required [redacted] clear draft and [redacted] armoring.

Prior to armoring, sediment profiling will be carried out to re-distribute sediments and level out the river bottom where mechanical dredging has occurred. This will create a smooth surface in advance of depositing stone armor. Sediment profiling will be accomplished by towing a 35-ton steel beam along the bottom and moving it slowly along the dredged area. The tugboat towing the beam will travel at approximately 1 knot (1.15 miles per hour or about 100’ per minute). In most areas, only one pass will need to be made; however, in limited areas, the beam will need to be towed through multiple times (up to three) to ensure a level profile. The contractor intends to complete sediment profiling prior to the end of the “dredge window” which extends until November 1. This activity will only take place in areas where dredging has occurred and is expected to take 6-8 days to complete.

### *3.4.4 Transport and Disposal of Dredged Material*

During each three-month period when dredging is occurring, dredged materials would be collected from the bottom of the river by barge-mounted cranes and placed into scows for subsequent disposal.

Each dredging stage would occur during a 90-day period, with dredging expected to occur every day during Stage 1 and 75 of the 90 days during Stage 2. Two dredges will operate during each dredging stage. During Stage 1, up to 6,800 cubic meters (8,900 cubic yards) of materials would be dredged each day. Table 2 presents the estimated daily volumes of materials removed for each dredging stage.

**Table 2**. Daily Materials Removal by Construction Stage

| **Dredge Stage** | **Daily Dredged Volume (cubic yards)** |
|---|---|
| Stage 1 | 8,900 |
| Stage 2 | 2,000 |

After placement in the scows, the scows will be towed to an offloading facility downriver. Dredged material would be transferred by barge to be offloaded at a facility in upper New York Harbor. Once it is processed, it will be transported over land to a permitted upland facility for disposal. In 2013, material was transported to five different facilities located in New Jersey between 31 and 39 miles downstream of the bridge site.

### *3.4.5 Pile Load Testing*

Prior to the start of bridge construction, [redacted] piles [redacted] were installed in the river as part of the contractor's geotechnical investigation and pile load testing. After load testing, the test piles will be cut and removed from the river. These piles were installed in the spring and summer of 2013.

### *3.4.6 Substructure Construction*

Substructure construction includes the pier pilings adjacent to the main span and locations along the approach span structure.

Substructure construction would vary as a function of water depth and sediment conditions at each location. Work on the foundation can be categorized [redacted]. [redacted] It is anticipated that the majority of initial installation will occur with a vibratory hammer, with 20-60 minutes of impact pile driving necessary to seat each pile.

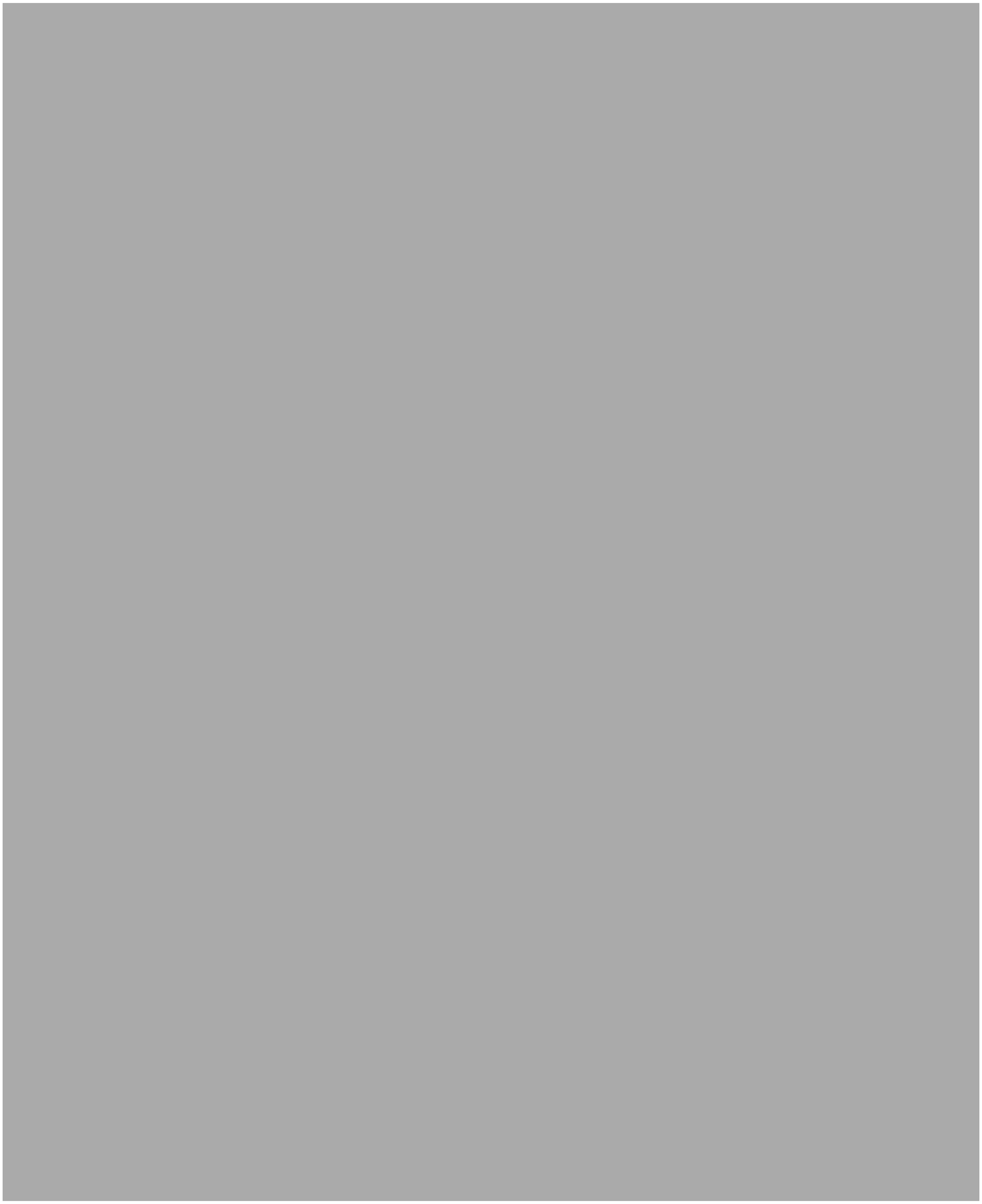
Substructure pile driving began on October 19, 2013 and occurred through December 7, 2013; permanent pile installation resumed on January 18, 2014. Through February 22, 2014, [redacted] piles were installed; the majority of pile installation was accomplished with a vibratory hammer. Impact pile driving time ranged from 0.17-1.53 hours (10-92 minutes) per pile.

Approach span piling driven from floating equipment will be installed in the following manner. A temporary frame and template secured by spud piles will be placed at the approach pier footing sites. The pilings will be driven through the temporary frame and template until installation is complete, at which time the temporary frame and template will be removed. Upon successful completion of the pile installation, a permanent precast foundation shell will be installed on the piles to facilitate the remaining foundation construction.

The main span piling driven from floating equipment will be installed in the following manner. A temporary frame and template secured by spud piles will be placed at the main pier footing sites. The pilings will be driven through the temporary frame and template until installation is complete, at which time the temporary frame and template will be removed. Upon successful completion of the pile installation, a temporary cofferdam will be hung from the permanent bridge piles to facilitate the remaining foundation construction.

Due to the length of the piles, most will be driven in multiple pieces with a field welded splice securing the sections of the pile. The lower section of the pile will be installed with a vibratory hammer, and the top section will be installed using a vibratory hammer or impact hammer or a combination of both. The upper section will be placed on the lower section and welded. The noise attenuation system will be installed and activated prior to impact driving. The final driving for all piles will be performed using a hydraulic impact hammer.

The pilings installed from the trestle will be installed within a steel sheet pile cofferdam.



### *3.4.7 Construction of Bridge Superstructure*

Completion of the bridge superstructure would include piers, columns, pylons (for a cable-stayed option), bridge deck, roadway finishes, lighting, and the shared use path. Much of the material would be pre-fabricated at various locations and delivered to the project site via barge. At the construction site, these elements would be lifted into place by gantries and cranes operating on barges, the temporary work platforms, or completed portions of the structure.

## 3.5 Existing Bridge Demolition

Bridge demolition work will not begin until traffic has been switched to the new West Bound Crossing. The major equipment that will be used to remove the existing bridge includes: barge mounted cranes; deck barges; tug boats; strand jacks for heavy lift lowering of sections of the trusses; false work for temporary bents; excavators with hoe rams; concrete debris clam buckets; and other support equipment.

The general sequence for the demolition will be to remove the portions of the existing bridge that would interfere with the completion of the new East Bound Crossing. This is the portion of the existing bridge that extends out from each abutment [redacted]. The demolition work will be completed concurrently at both the Rockland and Westchester approach spans. The complete superstructure and substructure units will be removed. The following is the bridge removal method:

- Install under deck shielding;
- Sawcut (diamond blade) the existing deck sections;
- Lift and remove the existing deck sections;
- Lift the existing under deck trusses with large floating barge mounted cranes and lower to deck barges;
- Demolish existing piers and abutments with conventional equipment: excavators with hoe rams and utility shears/pulverizers; and
- Remove concrete and debris from the river bed with concrete debris buckets and load onto material deck barges/scows.

The following is the sequence of work for the removal of the existing truss over the railroads:

- Install under deck shielding from pier-to-pier;
- Remove the existing deck and stringers with a crane on the deck level (sections trucked off bridge); and
- Remove the existing truss.

Prior to any demolition activities, the existing bridge will be tested for the presence of any lead-based paint. Lead abatement plans will be developed for any areas that will require remediation of lead. These areas will include the immediate areas where the existing bridge will be cut for removal. The required lead abatement will be performed prior to any demolition operations. This plan will be further developed in the Demolition and Removal plan.

## 3.6 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 work to construct the new bridge and remove the old bridge will take place, including dredging and armoring of the river bottom. The action area also includes the area of the river where increased underwater noise levels and changes in water quality will be experienced and the transit route that barges will use when transporting dredged material to the offloading site in upper New York Harbor for upland disposal. We anticipate that all effects of the action will occur within this geographic area. [redacted]

# 4.0 STATUS OF LISTED SPECIES IN THE ACTION AREA

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. We have determined that the actions being considered in the Opinion may adversely affect the following listed species:

| **Common name** | **Scientific name** | **ESA Status** |
|---|---|---|
| Shortnose sturgeon | *Acipenser brevirostrum* | Endangered |
| GOM DPS of Atlantic sturgeon | *Acipenser oxyrinchus oxyrinchus* | Threatened |
| New York Bight DPS of Atlantic sturgeon | *Acipenser oxyrinchus oxyrinchus* | Endangered |
| Chesapeake Bay DPS of Atlantic sturgeon | *Acipenser oxyrinchus oxyrinchus* | Endangered |

## 4.1 Shortnose Sturgeon

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). Individual 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

[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.

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 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 (Kynard et al. 2012).  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 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

[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.

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.

## 4.2 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 (77 FR 5880 and 77 FR 5914, February 6, 2012). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 4). 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 five DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

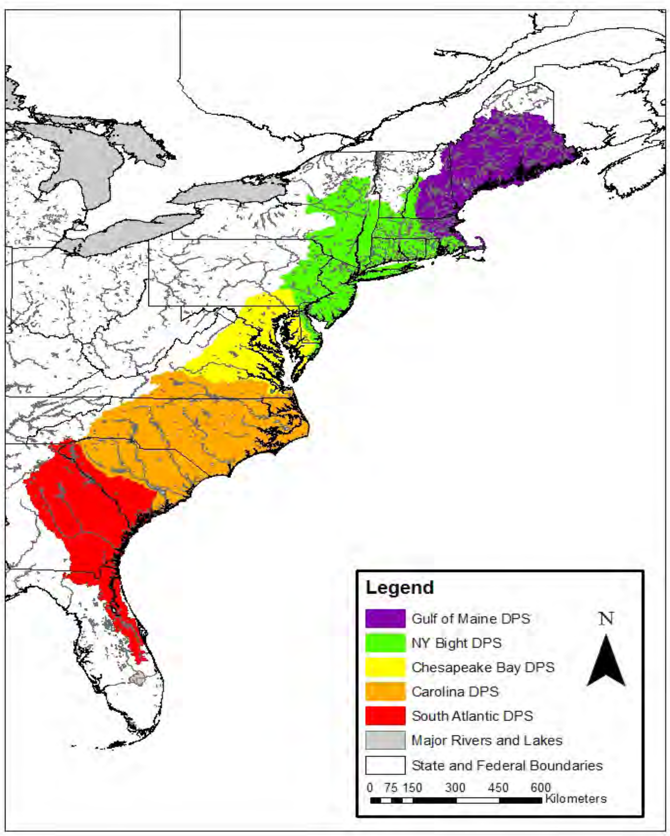
The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered, and the Gulf of Maine DPS is listed as threatened (77 FR 5880 and 77 FR 5914, February 6, 2012). The effective date of the listings was April 6, 2012. The DPSs do not include Atlantic sturgeon spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

As described below, individuals originating from three of the five listed DPSs are likely to 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.

### *4.2.1 Determination of DPS Composition in the Action Area*

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Hudson River. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Hudson River, and thereby, in the action area, will have originated from the Hudson River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Hudson River and estuary would not be limited to just individuals originating from the NYB DPS. Based on mixed-stock analysis, we have determined that subadult and adult 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).

**Figure 4.** Map Depicting the five Atlantic sturgeon DPSs



### 4.2.2 *Atlantic sturgeon life history*

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[3] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007).

The life history of Atlantic sturgeon can be divided up into five general categories as described in the table below (adapted from ASSRT 2007).

| Age Class | Size | Description |
|---|---|---|
| **Egg** | | Fertilized or unfertilized |
| **Larvae** | | Negative photo-taxic, nourished by yolk sac |
| **Young of Year (YOY)** | **0.3 grams <41 cm TL** | Fish that are > 3 months and < one year; capable of capturing and consuming live food |
| **Non-migrant juveniles** | **>41 cm and <76 cm TL** | Fish that are at least age 1 and are not sexually mature and do not make coastal migrations. |
| **Subadults** | **>76cm and <150cm TL** | Fish that are not sexually mature but make coastal migrations |
| **Adults** | **>150 cm TL** | Sexually mature fish |

**Table 4.** Descriptions of Atlantic sturgeon life history stages.

Atlantic sturgeon 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

[3] 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)

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 20$^{th}$ 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 (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.

### *4.1.2 Distribution and Abundance*

In the mid to late 19th century, Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing for the caviar market (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 River, 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 17 U.S. rivers are known to support spawning (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 five rivers (Kennebec, Androscoggin, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia, where historical records show that there used to be 15 spawning rivers (ASSRT 2007). Currently, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could slow the rate of recolonization of extirpated populations.

At the time of the listing, there were no current, published population abundance estimates for any of the currently known spawning stocks or 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 to 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 and Altamaha Rivers 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).

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NEFSC developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (see Kocik et al. 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (see Table 5). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the United States Fish and Wildlife Service (USFWS) sturgeon tagging database[4], and federal fishery discard estimates from 2006 to 2010 to produce a virtual population.

In additional to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 6). NEAMAP trawl surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall and spring. Fall surveys have been ongoing since 2007 and spring surveys since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

**Table 5.** Description of the ASPI model and NEAMAP survey based area estimate method.

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

**Table 6. Modeled Results**

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

[4] The USFWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag, release, and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery vessels.

The information from the NEAMAP survey can be used to calculate minimum swept area population estimates within the strata swept by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 7). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e. net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are with the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most species. The ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, but is certainly greater than one (i.e. the NEAMAP survey does not survey 100% of the Atlantic sturgeon habitat).

**Table 7.** Annual minimum swept area estimates for Atlantic sturgeon during the spring and fall from the Northeast Area Monitoring and Assessment Program survey. Estimates assume 100% net efficiencies. Estimates provided by Dr. Chris Bonzek, Virginia Institute of Marine Science (VIMS).

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

Available data do not support estimation of true catchabilty (i.e., net efficiency X availability) of the NEAMAP trawl survey for Atlantic sturgeon. Thus, the NEAMAP swept area biomass estimates were produced and presented in Kocik et al. (2013) for catchabilities from 5 to 100%. In estimating the efficiency of the sampling net, we consider the likelihood that an Atlantic sturgeon in the survey area is likely to be captured by the trawl. Assuming the NEAMAP surveys have been 100% efficient would require the unlikely assumption that the survey gear captures all Atlantic sturgeon within the path of the trawl and all sturgeon are within the sampling area of the NEAMAP survey. In estimating the fraction of the Atlantic sturgeon population within the sampling area of the NEAMAP, we consider that the NEAMAP-based estimates do not include young of the year fish and juveniles in the rivers where the NEAMAP survey does not sample. Although the NEAMAP surveys are not conducted in the Gulf of Maine or south of Cape Hatteras, NC, the NEAMAP surveys are conducted from Cape Cod to Cape Hatteras at depths up to 18.3 meters (60 feet), which includes the preferred depth ranges of subadult and adult Atlantic sturgeon. NEAMAP surveys take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. The NEAMAP estimates are minimum estimates of the ocean population of Atlantic sturgeon based on sampling in a large portion of the marine range of the five DPSs, in known sturgeon coastal migration areas during times that sturgeon are expected to be migrating north and south.

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

The ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey (see Table 5). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the U. S. Fish and Wildlife Service (USFWS) sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The NEAMAP estimate, in contrast, does not depend on as many assumptions. For the purposes of this Opinion, we consider the NEAMAP estimate resulting from the 50% catchability rate, as the best available information on the number of subadult and adult Atlantic sturgeon in the ocean.

The ocean population abundance of 67,776 fish estimated from the NEAMAP survey assuming 50% efficiency (based on net efficiency and the fraction of the total population exposed to the survey) was subsequently partitioned by DPS based on genetic frequencies of occurrence (Table 8) in the sampled area. Given the proportion of adults to subadults in the observer database (approximate ratio of 1:3), we have also estimated a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults.

The ASMFC has initiated a new stock assessment with the goal of completing it by the end of 2014. NMFS will be partnering with them to conduct the stock assessment, and the ocean population abundance estimates produced by the NEFSC will be shared with the stock assessment committee for consideration in the stock assessment.

**Table 8.** Summary of calculated population estimates based upon the NEAMAP Survey swept area assuming 50% efficiency (based on net efficiency and area sampled) derived from applying the Mixed Stock Analysis to the total estimate of Atlantic sturgeon in the Ocean and the 1:3 ratio of adults to subadults)

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

### *4.1.3 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).

Because a DPS is a group of populations, the stability, viability, and persistence of individual populations that make up the DPS can affect the persistence and viability of the larger DPS. The loss of any population within a DPS could result in: (1) a long-term gap in the range of the DPS that is unlikely to be recolonized; (2) loss of reproducing individuals; (3) loss of genetic biodiversity; (4) loss of unique haplotypes; (5) loss of adaptive traits; and (6) reduction in total number. The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, emigration to marine habitats to grow, and return of adults to natal rivers to spawn.

Based on the best available information, hawse have 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.

Individuals from all 5 DPSs are caught as bycatch in fisheries operating in U.S. waters. 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%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%.

## 4.2 Gulf of Maine DPS of Atlantic sturgeon

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 River, 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 17$^{th}$ 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. We 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 are known to 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. While not expected to be killed or injured during passage at a dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam, sturgeon can now travel as far upstream of the Great Works Dam. The Great Works Dam prevents Atlantic sturgeon from accessing the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. While removal of the Great Works Dams is anticipated to occur in the near future, the presence of this dam 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 affect 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.

Other than the ASPI and NEAMAP based estimates presented above, 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.

*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.

### 4.3 New York Bight DPS of Atlantic sturgeon

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 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-1970s (Kahnle *et al.*, 1998). A decline appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (Kahnle *et al.*, 1998; Sweka *et al.*, 2007; ASMFC, 2010). Catch-per-unit-effort 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. In addition to capture in fisheries operating in Federal waters, bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (shad) in the Hudson River, has now been closed and there is no indication that it will reopen soon. In the Hudson River sources of potential mortality include vessel strikes and entrainment in dredges.  Individuals are also exposed to effects of bridge construction (including the ongoing replacement of the Tappan Zee bridge).  Impingement at water intakes, including the Danskammer, Roseton and Indian Point power plants also occurs.   There is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800s indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman, 1999; Secor, 2002). Sampling in 2009 to target 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. We are also not able to quantify any effects to habitat.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks further upstream passage; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. Connectivity may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area.
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. NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning;

and (3) the impacts and threats that have and will continue to affect population recovery.

## 4.4 Chesapeake Bay DPS of Atlantic sturgeon

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).

Age to maturity for Chesapeake Bay DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 5 to 19 years for Atlantic sturgeon originating from South Carolina rivers (Smith *et al.*, 1982) and 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.*, 1998). Therefore, age at maturity for Atlantic sturgeon of the Chesapeake Bay DPS likely falls within these values.

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 pose 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). 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.

## 4.5 Shortnose Sturgeon in the Hudson River and the action area
The action area is limited to the reach of the Hudson River, 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.

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). [redacted] 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[5], 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); located more than 169 km (104 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

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[5] Based on information from the USGS gage in Albany (gage no. 01359139), in 2002 mean 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, water temperatures reached 8°C on April 11 and reached 15°C on May 19. In 2012, water temperatures reached 8°C on March 20 and reached 15°C on May 13.

adhere to solid objects on the river bottom (Buckley and Kynard 1981; Taubert 1980) and that 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 and 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; Indian Point is located near the northern edge of the bay) (Dovel et al. 1992; Geoghegan et al. 1992) by late fall and early winter. 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[6]. 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

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[6] 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. In 2011, water temperatures at the USGS gage at West Point, NY (No. 01374019) fell to 8°C on November 24. This gage ceased operations on March 1, 2012.

individuals tagged in 1995 in the overwintering area near Kingston, NY were later recaptured in the Connecticut River. One of these fish was at large for over two years and the other 8 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.

### 4.6 Atlantic sturgeon in the Hudson River and the action area

Use of the river by Atlantic sturgeon has been described by several authors. 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).

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.

## 4.7 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 (Section 5.0, below). Activities that impact sturgeon in the Hudson River but do not necessarily overlap with the action area are discussed below.

### *4.7.1 Hudson River Power Plants*

The mid-Hudson River provides cooling water to four large power plants: Indian Point Nuclear Generating Station, Roseton Generating Station (RM 66, rkm 107), Danskammer Point Generating Station (RM 66, rkm 107), and Bowline Point Generating Station (RM 33, rkm 52.8). All of these stations use once-through cooling. The Lovett Generating Station (RM 42, rkm 67) is no longer operating.

#### *4.7.1.1 Indian Point*

IP1 operated from 1962 through October 1974. IP2 and IP3 have been operational since 1973 and 1975, respectively. Since 1963, shortnose and Atlantic sturgeon in the Hudson River have been exposed to effects of this facility. Eggs and early larvae would be the only life stages of sturgeon small enough to be vulnerable to entrainment at the Indian Point intakes (openings in the wedge wire screens are 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. [redacted] 11 impinged shortnose sturgeon were recorded. [redacted] 251 Atlantic sturgeon were observed as impinged during this time period, with an annual range of 0-118 individuals (peak number in 1975); [redacted] 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; this consultation was subsequently reinitiated and a new Opinion was issued in January 2013. That Opinion considered effects of the continued operation of the Indian Point Nuclear Generating Station [redacted] Indian Point, IP2 and IP3 [redacted] pursuant to existing operating licenses and proposed renewed operating licenses to be issued to Entergy Nuclear Operations, Inc. (Entergy) by the NRC. In this Opinion, we conclude that the continued operation of IP2 and IP3 are likely to adversely affect but is not likely to jeopardize the continued existence of endangered shortnose sturgeon or the Gulf of Maine, New York Bight or Chesapeake Bay DPS of Atlantic sturgeon.

This ITS exempts the following take:

- A total of 2 dead or alive shortnose sturgeon (injure, kill, capture or collect) and 2 dead or alive New York Bight DPS Atlantic sturgeon (injure, kill, capture or collect) impinged [redacted] intakes (Ristroph screens) from now until the IP2 proposed renewed operating license would expire on September 28, 2033.
- A total of 395 dead or alive shortnose sturgeon (injure, kill, capture or collect) and 269 New York Bight DPS Atlantic sturgeon (injure, kill, capture or collect) impinged

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[redacted]

[redacted] intakes (Ristroph screens) from now until the IP2 proposed renewed operating license would expire on September 28, 2033.

- A total of 167 dead or alive shortnose sturgeon (injure, kill, capture or collect) and 145 dead or alive New York Bight DPS Atlantic sturgeon (injure, kill, capture or collect) impinged at the Unit 3 intakes (Ristroph screens) from now until the IP3 proposed renewed operating license would expire on December 12, 2035.
- All shortnose sturgeon with body widths greater than 3” impinged at the IP1, IP2 and IP3 trash racks (capture or collect).
- All Atlantic sturgeon with body widths greater than 3” impinged at the IP1, IP2 and IP3 trash racks (capture or collect). These Atlantic sturgeon will originate from the New York Bight (92%), Gulf of Maine (6%) and Chesapeake Bay DPSs (2%).

This ITS applies to the currently authorized operating periods and the proposed extended operating periods. The ITS specifies reasonable and prudent measures necessary to minimize and monitor take of shortnose and Atlantic sturgeon.

*7.4.1.2 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.[8] 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

[8] 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.

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. 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.

## 5.0 ENVIRONMENTAL BASELINE

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

## 5.1 Federal Actions that have Undergone Formal or Early Section 7 Consultation

### *5.1.1 Scientific Studies permitted under Section 10 of the ESA*

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 three 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.

NYSDEC holds a scientific research permit (#16439, which replaces their previously held permit #1547) authorizing the assessment of 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). NYSDEC 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. The unintentional mortality of nine shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on November 24, 2016.

In April 2012, NYSDEC was issued a scientific research permit (#16436) which authorizes the capture, handling and tagging of Atlantic sturgeon in the Hudson River. NYSDEC is authorized to capture 1,350 juveniles and 200 adults. The unintentional mortality of two juveniles is anticipated annually over the five year life of the permit. This permit expires on April 5, 2017.

A permit was issued to Dynegy[9] in 2007 (#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. This permit was reissued to Entergy in August 2012 as permit #17095; the permit will expire in 2017. The permit holders are authorized to capture up to 82 shortnose sturgeon adults/juveniles and 82 Atlantic sturgeon annually to measure, weigh, tag, photograph, and collect tissue samples for genetic analyses. The permit also authorizes the lethal take of up to 40 larvae of each species annually. No lethal take of any juvenile, subadult or adult sturgeon is authorized.

### *5.1.2 Hudson River Navigation Project*

The Hudson River navigation project authorizes a channel 600 feet wide, New York City to Kingston narrowing to 400 feet wide to 2,200 feet south of the Mall Bridge (Dunn Memorial Bridge) at Albany with a turning basin at Albany and anchorages near Hudson and Stuyvesant, all with depths of 32 feet in soft material and 34 feet in rock; then 27 feet deep and 400 feet wide to 900 feet south of the Mall Bridge (Dunn Memorial Bridge); then 14 feet deep and generally 400 feet wide, to the Federal Lock at Troy; and then 14 feet deep and 200 feet wide, to the southern limit of the State Barge Canal at Waterford; with widening at bends and widening in front of the cities of Troy and Albany to form harbors 12 feet deep. The total length of the existing navigation project (NYC to Waterford) is about 155 miles. The only portion of the channel that is regularly dredged is the North Germantown and Albany reaches. Dredging is scheduled at times of year when sturgeon are least likely to be in the dredged reaches; no interactions with sturgeon have been observed.

### *5.1.3 Tappan Zee 2012 Pile Installation Demonstration Project*

[9] 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."

A PIDP was conducted from April 23 to May 20, 2012 to: 1) assess the geotechnical aspects [redacted]) collect hydroacoustic monitoring data on underwater noise levels generated by the PIDP pile driving operations; 3) evaluate the effectiveness of several noise attenuation systems for minimizing noise impacts to Hudson River fishes; and 4) monitor for the presence of acoustic-tagged fishes, including Atlantic sturgeon, and evaluate their behavioral response to the underwater noise associated with pile driving activities.

The PIDP included the installation and testing of seven steel piles, clustered at four locations across the Hudson River, immediately to the north of the existing Tappan Zee Bridge. Additionally [redacted] small ancillary piles [redacted] ere installed. Consultation on the effects of the proposed PIDP was completed with the issuance of a Biological Opinion on March 7, 2012. 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 GOM DPS of Atlantic sturgeon, the endangered NYB DPS of Atlantic sturgeon or the endangered CB DPS of Atlantic sturgeon.

Our Opinion included an Incidental Take Statement (ITS) exempting the following take:

- A total of no more than 19 shortnose sturgeon injured during the installation of the [redacted] 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 [redacted] 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 injured or dead sturgeon were observed during the PIDP. More information on the PIDP is included in section 7.2.2. of this Opinion.

#### *5.1.4 Other Federally Authorized Actions*

We have completed several informal consultations on effects of in-water construction activities in the Hudson River and New York Harbor permitted by the ACOE. This includes several dock and pier projects. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

We have also completed several informal consultations on effects of private dredging projects permitted by the ACOE. All of the dredging was with a mechanical dredge. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

### 5.2 State or Private Actions within the Action Area

#### *5.2.1 Existing Tappan Zee Bridge*

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.

### *5.2.2 State Authorized Fisheries*

Atlantic and shortnose sturgeon may be vulnerable to capture, injury and mortality in fisheries occurring in state waters. The action area includes portions of New York and New Jersey state waters. Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. We are currently working with the Atlantic States Marine Fisheries Commission (ASMFC) and the coastal states to assess the impacts of state authorized fisheries on sturgeon. We anticipate that some states are likely to apply for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no applications have been submitted. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon. Some of these fisheries occur in the Hudson River or lower estuary where both Atlantic and shortnose sturgeon occur (i.e., American eel, shad and river herring, striped bass, croaker and weakfish); other fisheries occur only in marine waters where only Atlantic sturgeon are likely to occur (coastal sharks, horseshoe crabs, American lobster).

*American Eel*

American eel (*Anguilla rostrata*) is exploited in fresh, brackish and coastal waters from the southern tip of Greenland to northeastern South America. American eel fisheries are conducted primarily in tidal and inland waters. In the Hudson River, eels between 6 and 14 inches long may be kept for bait; no eels may be kept for food (due to potential PCB contamination). Eels are typically caught with hook and line or with eel traps and may also be caught with fyke nets. Sturgeon are not known to interact with the eel fishery.

*Atlantic croaker*

Atlantic croaker (*Micropogonias undulates*) occur in coastal waters from the Gulf of Maine to Argentina, and are one of the most abundant inshore bottom-dwelling fish along the U.S. Atlantic coast. Fishing for Atlantic croaker may occur in the Hudson River estuary as well as in coastal waters considered as part of the action area. Atlantic croaker are managed under an ASMFC ISFMP (including Amendment 1 in 2005 and Addendum 1 in 2010), but no specific management measures are required. New York currently has no recreational or commercial management measures in place.

Recreational fisheries for Atlantic croaker are likely to use hook and line; commercial fisheries targeting croaker primarily use otter trawls. A review of the NEFOP database indicates that from 2006-2010, 60 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as croaker. This represents a minimum number of Atlantic sturgeon captured in the croaker fishery during this time period as it only considers observed trips. We do not have an estimate of the total number of Atlantic sturgeon caught as bycatch in the croaker fishery or the portion of the bycatch that occurs in the action area. Mortality of Atlantic sturgeon in commercial otter trawls has been estimated at 5%; we expect a similar mortality rate for Atlantic sturgeon bycatch in the croaker fishery operating in the action area. No information on interactions between shortnose sturgeon and the croaker fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

*Coastal sharks*
ASMFC manages coastal sharks through an Interstate Fishery Management Plan, which mirrors NMFS regulations regarding opening and closing dates, as well as quotas. New York prohibits commercial and recreational fishing for 20 species of sharks in state waters (the prohibited and research groups, as defined by the ASMFC's ISFMP). The commercial fishery for non-sandbar large coastal sharks closes when federal waters are closed by NMFS. No person is allowed to possess more than 33 sharks, regardless of species, in any 24-hour period. Commercial fishermen may use hook and line, small and large mesh gillnets, trawl nets, shortlines, weirs, and pound nets, while recreational anglers may only catch sharks using handlines or rod and reel. Commercial fishermen must practice bycatch reduction measures when using shortlines and large mesh gillnet fisheries, including release and disentanglement procedures for sea turtles. New York allows recreational fishermen to take only 20 species of sharks, with minimum size limits of 54 inches, except for Atlantic sharpnose, finetooth, blacknose, bonnethead, smooth dogfish, and spiny dogfish, which have no minimum size restrictions. Recreational shore and vessel-based anglers are limited to one shark plus an additional Atlantic sharpnose and bonnethead, and unlimited numbers of smooth and spiny dogfish. Atlantic sturgeon are known to interact with hook and line fisheries using live bait, as well as with large mesh gillnets and otter trawls; thus, some Atlantic sturgeon are likely captured during fishing targeting coastal sharks, although no estimates of the level of interaction are available.

*Horseshoe crabs*
ASMFC manages horseshoe crabs through an Interstate Fisheries Management Plan that sets state quotas, and allows states to set closed seasons. New York is allowed 366,272 crabs by the ASMFC under Addendum IV, but has issued a lower state quota of 170,000. Commercial horseshoe crab harvester may take 30 crabs per day during the open season by hand harvest or with pound nets, trap nets, gillnets, otter trawls, seines, or dredges. The use of dredges is prohibited in September and October, and dredges are limited to six feet in width at other times. Recreational harvesters are allowed to take five crabs per person per day, all year. Once the ASMFC quota is reached, the fishery is closed. Trawls are known to incidentally capture Atlantic sturgeon. Stein *et al.* (2004) examined bycatch of Atlantic sturgeon using the NMFS sea-sampling/observer database (1989-2000) and found that the bycatch rate for horseshoe crabs was

very low, at 0.05%. Few Atlantic sturgeon are expected to be caught in the horeshoe crab fishery in the action area.

*Shad and River herring*

Shad and river herring (blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengus*)) are managed under an ASMFC Interstate Fishery Management Plan. In 2005, the ASMFC approved a coastwide moratorium on commercial and recreational fishing for shad. In May 2009, ASMFC adopted Amendment 2 to the ISFMP for Shad and River Herring, which closes all recreational and commercial fisheries unless each state can show its fisheries are sustainable. New York has submitted a Sustainable Fishing Plan that is currently under review. The plan prohibits the taking of river herring in any state waters, except for Hudson River stocks, for which it proposes partial closure in the tributaries and a five-year commercial gillnet fishery in the lower river. Although now closed, in the past this fishery was known to capture Atlantic and shortnose sturgeon.

*Striped bass*

Fishing for striped bass occurs within the Hudson River as well as in marine waters. Striped bass are managed by ASMFC through Amendment 6 to the Interstate FMP, which requires minimum sizes for the commercial and recreational fisheries, possession limits for the recreational fishery, and state quotas for the commercial fishery (ASMFC 2003). Under Addendum 2, the coastwide striped bass quota remains the same, at 70% of historical levels. Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the striped bass fishery accounted for 43% of Atlantic sturgeon recaptures; however, no information on the total number of Atlantic sturgeon caught by fishermen targeting striped bass is available. No information on interactions between shortnose sturgeon and the striped bass fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

*Weakfish*

The weakfish fishery occurs in both state and federal waters but the majority of commercially and recreationally caught weakfish are caught in state waters (ASMFC 2002). Fishing for weakfish could occur in the Hudson River estuary as well as in marine waters. The dominant commercial gears include gill nets, pound nets, haul seines, and trawls, with the majority of landings occurring in the fall and winter months (ASMFC 2002).

A quantitative assessment of the number of Atlantic sturgeon captured in the weakfish fishery is not available. A review of the NEFOP database indicates that from 2006-2010, 36 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as weakfish. This represents a minimum number of Atlantic sturgeon captured in the weakfish fishery during this time period as it only considers observed trips, and most inshore fisheries are not observed. An earlier review of bycatch rates and landings for the weakfish fishery reported that the weakfish-striped bass fishery had an Atlantic sturgeon bycatch rate of 16% from 1989-2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of .02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007). No information on interactions between shortnose sturgeon and the weakfish fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

*American lobster trap fishery*
An American lobster trap fishery also occurs in state waters. Atlantic sturgeon are not known to interact with lobster trap gear.

## 5.3 Other Impacts of Human Activities in the Action Area

### *5.3.1 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 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.)

## 5.4 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 portion of the action area where construction will take place 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 construction portion of 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, juvenile, subadult and adult Atlantic sturgeon may be present in the construction portion of the action area year round. As explained above, all juvenile Atlantic sturgeon in the action area originate from the Hudson River and the NYB DPS. Adult and subadult 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 Hudson River portion of 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.

# 6.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change in the action area and how listed sturgeon may be affected by those predicted environmental changes over the life of the proposed action. Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Effects of the proposed action that are relevant to climate change are included in the Effects of the Action section below (section 7.0 below).

## 6.1 Background Information on predicted 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). 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 have been most apparent over the past few decades.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3$^{o}$-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 rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 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).

## 6.2 Species Specific Information Related to Predicted Impacts of Climate Change

### *6.2.1 Shortnose sturgeon*

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

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

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

### *6.2.2 Atlantic sturgeon*

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

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

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

## 6.3 Potential Effects of Climate Change in the Action Area

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 of a shift in the salt wedge include restricting the habitat available for early life stages and juvenile 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°F) 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.

Sea surface temperatures have fluctuated around a mean for much of the past century, as measured by continuous 100+ year records at Woods Hole (Mass.), and Boothbay Harbor (Maine) and shorter records from Boston Harbor and other bays. Periods of higher than average temperatures (in the 1950s) and cooler periods (1960s) have been associated with changes in the North Atlantic Oscillation (NAO), which affects current patterns. Over the past 30 years however, records indicate that ocean temperatures in the Northeast have been increasing; for example, Boothbay Harbor's temperature has increased by about 1°C since 1970. While we are not able to find predictive models for New York, given the geographic proximity of these waters to the Northeast, we assume that predictions would be similar. For marine waters, the model projections are for an increase of somewhere between 3-4°C by 2100 and a pH drop of 0.3-0.4 units by 2100 (Frumhoff *et al.* 2007). Assuming that these predictions also apply to the action area, one could anticipate similar conditions in the action area over that same time period.

## 6.4 Effects of Climate Change in the Action Area to Atlantic and shortnose sturgeon

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 and Atlantic 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. Upstream shifts in spawning or rearing habitat in the Hudson River are limited by the existence of the Troy Dam (RKM 250, RM 155), which is impassable by sturgeon. Currently, the saltwedge normally shifts seasonally from Yonkers to as far north as Poughkeepsie (RKM 120, RM 75). Given that sturgeon currently have over 75 miles of habitat upstream of the salt wedge before the Troy Dam, it is unlikely that the saltwedge would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. The available habitat for juvenile sturgeon could decrease over time; however, even if the saltwedge shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon because there would still be many miles of available low salinity habitat between the salt wedge and the Troy Dam.

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 sturgeon move to spawning and overwintering grounds. There could be shifts in the timing of spawning; presumably, if water temperatures warm earlier in the spring, and water temperature is a primary spawning cue, spawning migrations and spawning events could occur earlier in the year. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of sturgeon through the action area.

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

Limited information on the thermal tolerances of Atlantic and shortnose sturgeon is available. Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C. In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). Tolerance to temperatures is thought to increase with age and body size (Ziegweid *et al.* 2008 and Jenkins *et al.* 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. Shortnose sturgeon, have been documented in the lab to experience mortality at temperatures of 33.7°C (92.66°F) or greater and are thought to experience stress at temperatures above 28°C. For purposes of considering thermal tolerances, we consider Atlantic sturgeon to be a reasonable surrogate for shortnose sturgeon given similar geographic distribution and known biological similarities.

Normal surface water temperatures in the Hudson River can be as high as 24-27°C at some times and in some areas during the summer months; temperatures in deeper waters and near the bottom are cooler. A predicted increase in water temperature of 3-4°C within 100 years is expected to result in temperatures approaching the preferred temperature of shortnose and Atlantic sturgeon (28°C) on more days and/or in larger areas. This could result in shifts in the distribution of sturgeon out of certain areas during the warmer months. Information from southern river systems suggests that during peak summer heat, sturgeon are most likely to be found in deep water areas where temperatures are coolest. Thus, we could expect that over time, sturgeon would shift out of shallow habitats on the warmest days. This could result in reduced foraging opportunities if sturgeon were foraging in shallow waters.

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. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species which may allow them to deal with change better than predicted.

## 7.0 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 three 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.

NYSDEC issued a permit to the NYSTA authorizing the construction and demolition of the new Tappan Zee Bridge on March 27, 2013. This permit is issued under the following authorities: Tidal Wetlands – ECL Article 25 (Permit ID 3-9903-00043/00012); Section 401 Water Quality Certification – ECL Article 15 (Permit ID 3-9903-00043/00013); and, Endangered/Threatened Species (Incidental Take) – ECL Article 11 (Permit ID 3-9903-00043/00014). All three authorizations expire on March 24, 2019. The permit requires the implementation of an Endangered and Threatened Species Mitigation Plan and a Compensatory Mitigation Plan as well as compliance with a number of permit conditions. We have considered whether the measures required by this permit fit the definitions of indirect effects or interrelated or interdependent actions. Both the Endangered and Threatened Species Mitigation Plan and the Compensatory Mitigation Plan meet the definition of interrelated actions. The mitigation plans are interrelated action because they are part of the Tappan Zee Bridge replacement project and rely on the bridge replacement project for their justification. That is, these two mitigation plans would not occur "but for" the bridge replacement project. Therefore, to the extent possible, we will consider the effects of the mitigation plans in this Opinion. We have not identified any other interrelated or interdependent activities.

The proposed action has the potential to affect shortnose and Atlantic sturgeon in several ways: dredging; changes to habitat from armoring the river bottom; exposure to increased underwater noise resulting from pile installation; vessel interactions; changes in water quality, including TSS; and, altering the abundance or availability of potential prey items. The effects analysis below is organized around these topics. We also consider effects of the required mitigation plans.

## 7.1 Dredging the Access Channel and Use of Bed Leveler

### *7.1.1 Overview of Dredging Activity*

As described in Section 3.4.2, dredging will occur in two years, between August 1 and November 1. [redacted] All dredging will be completed with a closed environmental bucket.

The first stage of dredging occurred in 2013. Two dredges were used between August 2 and October 30, 2013 [redacted] All material was transported to one of five facilities in New Jersey, located [redacted] downstream from the dredge site, where it was offloaded and processed for upland disposal. NMFS-approved observers were present to monitor 100% of all dredging. All dredge observer forms were submitted to us on December 31, 2013. While fish and other biological materials were observed [redacted] no shortnose or Atlantic sturgeon were observed. Observations were mostly of eels as well as oysters, oyster shells and crabs. The second phase of dredging is scheduled to occur between August 1 and November 1, 2014.

Bucket dredges are relatively stationary. While operating, the dredge swings slowly in an arc across the channel cut as material is excavated. This is accomplished by pivoting the dredge on vertical pilings called spuds that are alternately raised and lowered from the stern corners of the dredge. Cables to anchors set roughly perpendicular to the forward section of the dredge are used to shift the lateral position of the digging area. Periodically, as the cut advances, the anchors are reset. Bucket dredging entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the bucket up through the water column, and emptying the bucket into a barge. An environmental clamshell dredge differs from traditional dredging buckets by having an outer covering that seals when the bucket is closed. Water passes through its top moveable vents as it submerges, thereby reducing turbidity. Once it lifts off the bottom and closes, the covering seals over the bucket and minimizes overspill as the dredge bucket moves back up through the water column.

### *7.1.2 Capture of sturgeon in the dredge bucket*

Aquatic species can be captured in dredge buckets and can be injured or killed if entrapped in the bucket or buried in sediment during dredging and/or when sediment is deposited into the dredge scow. Fish captured and emptied out of the bucket can suffer stress or injury, which can lead to mortality.

In 2012, USACE provided NMFS with a list of all documented interactions between dredges and sturgeon reported along the U.S. East Coast; reports dated as far back as 1990 (USACE 2012). This report includes four incidences of sturgeon captured in dredge buckets. One of these was in the Cape Fear River (Atlantic sturgeon) and the other three were at the Bath Iron Works (BIW) facility in the Kennebec River, Maine. Very few mechanical dredge operations have employed observers to document interactions between sturgeon and the dredge; because of that we do not know if the lack of observations is a result of fish not being captured at other projects or that captures occur but are not observed. Captures of two shortnose and one Atlantic sturgeon have been documented at BIW in the Kennebec River, Maine. Observer coverage at dredging operations at BIW has been 100% for approximately 15 years, with dredging occurring every one to two years.

The risk of interactions between sturgeon and dredges is thought to be highest in areas where large numbers of sturgeon are known to aggregate, such as overwintering sites or foraging concentrations. The BIW facility, where nearly all recorded interactions between sturgeon and bucket dredges have occurred, is in area where foraging sturgeon are known to aggregate in the summer months. The risk of capture may also be related to the behavior of the sturgeon in the area. While foraging, sturgeon are at the bottom of the river interacting with the sediment. This behavior may increase the susceptibility of capture with a dredge bucket. The risk may be higher in areas where high numbers of sturgeon are present in a small area as this could increase the likelihood of an interaction.

Due to the rarity of recorded interactions between sturgeon and mechanical dredge operations, it is difficult to predict the number of interactions that are likely to occur from a particular dredging operation. Projects that occur in an identical location with the same equipment year after year may result in interactions in some years and none in other years. For example, dredging in the BIW sinking basin prior to 2003 resulted in no interactions with shortnose sturgeon but one shortnose sturgeon was killed by the clamshell dredge in the last hour of the last day of dredging of a dredge event running from April 7 to April 30, 2003. An additional shortnose sturgeon was captured in this area in 2009, but none were captured between 2003 and 2009 or 2009-2012. Regardless, based on all available evidence, the risk of capture in a mechanical dredge is low due to the slow speed at which the bucket moves and the relatively small area of the bottom it interacts with at any one time and because a sturgeon would have to be present at the exact site of impact of the dredge bucket with the river bottom in order to be captured.

Based on the occurrence of shortnose and Atlantic sturgeon in the area where mechanical dredging will take place and the documented vulnerability of this species to capture with mechanical dredges, the potential exists for sturgeon to be captured by the mechanical dredge working to dredge the access channel. Due to the relatively low level of risk that an individual shortnose or Atlantic sturgeon would be captured in the slow moving dredge bucket, no more than one shortnose sturgeon and no more than one Atlantic sturgeon is likely to be captured during each year that dredging occurs. In our 2013 Opinion, we predicted that two or fewer shortnose sturgeon and two or fewer Atlantic sturgeon to be captured during dredging over the two year period. This was based on an expectation of an interaction with one shortnose and one Atlantic sturgeon during each year of dredging. This predicted level of capture is similar to the amount of capture that occurs at the BIW facility which is the only other bucket dredging project for which capture of Atlantic and shortnose sturgeon has been reported. One year of dredging has now been completed; no shortnose or Atlantic sturgeon were observed. Because the observers were able to see organisms that are significantly smaller than shortnose and Atlantic sturgeon (i.e., eels, crabs, oysters), we expect that if any sturgeon were captured they would have been seen. The results of the 2013 dredging confirm our assumption that the likelihood of interactions is low. However, because we know shortnose and Atlantic sturgeon can be captured in dredge buckets and because we know they occur in the area being dredged and due to the length of time that dredging will occur (i.e., 24 hours per day for up to three months), it is reasonable to expect that an interaction will occur in 2014. As such, we expect the capture of no more than one shortnose and one Atlantic sturgeon during the second phase of dredging.

Sturgeon captured in the dredge bucket could be injured or killed. Sources of mortality include injuries suffered during contact with the dredge bucket or burial in the dredge scow. Of the three captures of sturgeon with mechanical dredges in the Kennebec River (two shortnose (in 2003 and 2009), one Atlantic (in 2001)), one of the shortnose sturgeon was killed. This fish was killed during the last hour of a 24-hour a day dredging operation that had been ongoing for approximately four weeks. This fish suffered from a large laceration, likely experienced due to contact with the dredge bucket. Of the other two fish, both were observed alive in the dredge scow and were released, with no visible external injuries. Assuming that the risk of mortality once captured is similar across dredging projects, we expect a similar mortality rate at the Tappan Zee project as has been observed at BIW. Therefore, we expect that the captured shortnose sturgeon and captured Atlantic sturgeon will be injured or killed during dredging operations. Injury or mortality could result from contact with the dredge bucket or through suffocation due to burial in the scow. Because FHWA will require an observer be present to watch for captured fish as sediment is deposited in the scow and to monitor the scow for fish, we expect that any captured sturgeon will be documented.

Shortnose sturgeon captured or killed could be juveniles or adults.

During the time of year that dredging will occur (August 1 – November 1), only juvenile and subadult Atlantic sturgeon are likely to be present in the area to be dredged. Therefore, the affected Atlantic sturgeon will be juveniles or subadults. Based on the mixed-stock analysis, it is most likely that the captured Atlantic sturgeon, including the one that could be killed, would originate from the New York Bight DPS. However, because Atlantic sturgeon from the

Chesapeake Bay and Gulf of Maine DPSs are also present in the area where dredging will occur, it is possible that one of the captured or killed fish could originate from either the Chesapeake Bay or Gulf of Maine DPS; these fish would be subadults because juveniles remain in their natal rivers and therefore, juveniles from these DPSs do not occur in the action area.

#### *7.1.3 Effects of Bed Leveling*
While the bed leveler is very heavy, it moves very slowly (1 knot). Any sturgeon that are in the area are expected to move away from the slowly moving beam and we do not anticipate that any sturgeon will be struck or crushed by the beam. No reports of injured or dead sturgeon have been reported in association with any bed leveling activities in the U.S. Bed leveling occurred at the end of dredging in 2013 and there were no observations of sturgeon during this time. We do not anticipate any shortnose or Atlantic sturgeon to be injured or killed if a bed leveler is used.

Effects of the bed leveler on turbidity and benthic resources are discussed below (section 7.6 and 7.5, respectively).

### 7.2 Pile Installation
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 also present the results of the 2012 PIDP. 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.

As noted in Section 3.0, installation of test piles for the second PIDP has been completed and installation of permanent bridge piles began in October 2013. Through the end of 2013 (last date of pile installation was December 7), [redacted] piles were installed. No injured or dead shortnose or Atlantic sturgeon were observed during pile installation. The project team is monitoring the use of the area with acoustic receivers which detect the presence of sturgeon carrying acoustic tags. Information on the use of the action area by tagged sturgeon is not yet available for the October – December period when pile driving was occurring.

#### *7.2.1 Information Used to Conduct the Effects Analysis*

##### *7.2.1.1 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 can hear sounds to about 4,000 Hz, while a few, 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 $1\mu Pa^2$-s.

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

- Cumulative SEL (cSEL or $SEL_{cum}$):  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.

*7.2.1.2 Summary of Available Information on Underwater Noise and Sturgeon*

Sturgeon 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 is little 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.

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 on tissues contacting the swim bladder 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 feet from a 1.5 foot diameter pile and exposed to over 1,600 strikes. As noted above, species are thought to 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.* 2012)

Halvorsen et al. (2012) conducted studies on the effects of exposure to pile-driving sounds on lake sturgeon, Nile tilapia and hogchoker using a specially designed wave tube. The three species tested were chosen partly because they each have different types of swim bladders. The lake sturgeon, like Atlantic and shortnose sturgeon, has an open (physostomous) swim bladder (connected to the gut via a pneumatic duct); the Nile tilapia has a closed (physoclistous) swim bladder containing a gas gland that provides gas exchange by diffusion to the blood; the hogchocker does not have a swim bladder. Lake sturgeon used in this experiment were 3 to 4 months old and were approximately 60-70 mm in length and weighed 1.2 -2.0 grams (n=141). Tested fish were exposed to five treatments of 960 pile strikes with SELcum ranging from 216 dB re 1uPa2s to 204 dB re 1uPa2s. All fish were euthanized after the experiment and examined for internal injury. None of the fish died during the experiment. No lake sturgeon demonstrated any external injuries; internal evaluation showed hematomas on the swim bladder, kidney and intestine and partially deflated swim bladders. Injuries were only observed in lake sturgeon exposed to cSEL greater than 210 dB re 1uPa2s. All sturgeon were exposed to all 960 pile strikes and only cumulative sound exposure was tested during this study. No behavioral responses are reported in the paper.

*7.2.1.3 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).

At this time, these criteria 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 $\mu Pa^2 \cdot s$ 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 $\mu Pa^2$-s cSEL. Use of the 183 dB re 1 $\mu Pa^2$-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.

*7.2.1.4 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 the 150 dB re 1 µPa RMS criterion as an indication for when behavioral effects could be expected. With the exception of studies carried out during the first Tappan Zee PIDP (AKRF and Popper 2012a,b), 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; however, FHWA does not suggest any alternative criteria for assessing the potential for behavioral responses. 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.

### *7.2.2 Summary of the 2012 PIDP and associated sturgeon tag detection studies*

A PIDP was conducted from April 23 to May 20, 2012 to: 1) assess the geotechnical aspects of the construction site; 2) collect hydroacoustic monitoring data on underwater noise levels generated by the PIDP pile driving operations; 3) evaluate the effectiveness of several noise attenuation systems for minimizing noise impacts to Hudson River fishes; and 4) monitor for the presence of acoustic-tagged fishes, including Atlantic sturgeon, and evaluate their behavioral response to the underwater noise associated with pile driving activities.

The PIDP included the installation and testing of [redacted] steel piles, clustered at [redacted] locations across the Hudson River, immediately to the north of the existing Tappan Zee Bridge. Additionally, [redacted] small ancillary piles [redacted] were installed. The [redacted] locations were selected to represent distinct geological stratigraphies encountered along the approximately three-mile span of the crossing alignment.

[redacted] piles were installed in the deeper sediments on [redacted] side of the river channel. A [redacted] pile were each installed on the [redacted] side of the navigation channel where thin sediment overlies sandstone. One [redacted] pile was installed on the [redacted] side of the navigation channel where gneiss bedrock exists. Piles were installed on seven days between late April and late May 2012. No more than one test pile was installed per day with 1-5 hours of driving for each pile.

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

The [redacted] small ancillary piles were installed using a vibratory hammer. Installation of the ancillary piles was completed in less than three days at each location. Pile driving was accomplished with a hammer suspended from a crane operating from a moored barge. The piles were installed in two pieces, a lower section [redacted] and an upper section [redacted]. The two sections were connected by welding. Vibratory hammers were used to drive the bottom segments and a combination of vibratory and impact hammers were used to drive the top segments.

The on-site crew worked from two material barges, one crane barge, and one tugboat. Low-draft [redacted] vessels were used for personnel movements between the workboats. [redacted]

[redacted]

The PIDP contractor utilized a turbidity curtain (i.e., silt curtain) around each work area in order to limit the potential for downstream transport of any fine sediment. The PIDP included site-specific testing of a range of hydroacoustic mitigation or noise attenuation systems that could be used in future construction work for the new bridge. The project team tested bubble curtains (both single ring and multiple ring options, including the Gunderboom technology), isolation casings (a large pile in which the test pile is driven), and combined casing and bubble systems. The purpose of the sound attenuation system trials was to provide site-specific information about the performance of the systems in order to:

- Assess practical aspects of the site-specific implementation of these systems in the context of water currents, water depth, and other pile-driving conditions that are specific to the project area;
- 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.

After completion of the PIDP, the load frames, load test equipment, and ancillary piles were removed. [redacted]

During pile driving, sound levels were measured at a nominal range [redacted] from the piles. The actual test pile installation differed from scenarios modeled by the project team in that: (1) the contractor used more vibratory pile driving and less impact pile driving; and, (2) there were construction barges with drafts [redacted] surrounding the test piles, potentially obstructing the extent of sound transmission.

Measured propagation losses for impact pile driving were much larger than the losses predicted by the hydroacoustic model (JASCO 2012), meaning sound attenuated much more rapidly than previously predicted. Therefore, distances to the $SPL_{peak}$, rms SPL, and $SEL_{cum}$ thresholds were considerably smaller than predicted in the FEIS and in our 2012 Biological Opinion. FHWA has prepared revised estimates of pile driving noise for the bridge replacement based on the PIDP results (see below).

Data from the PIDP indicate that the previous modeling results overestimate the expected sound levels likely to occur during actual bridge construction. The construction barges surrounding the piles appeared to have attenuated noise considerably, thereby decreasing the size of the ensonified area. Furthermore, the PIDP demonstrated that more vibratory hammering and less impact pile driving will occur during installation than was previously anticipated. The noise measurements taken during the PIDP are, therefore, considered useful for predictive purposes, since both the construction barges surrounding the piles and the greater use of vibratory hammers are expected to reflect proposed bridge construction conditions and are the same pile materials, installation methods, substrate types. Therefore, using the PIDP results to predict noise levels associated with pile installation during bridge construction is reasonable.

All the tested noise attenuation systems met the criterion of 10 dB SEL attenuation. Based on short-range measurements, acoustic attenuations of the five tested systems were:

- 12.2–17.0 dB reduction in $SPL_{peak}$
- 10.8–16.1 dB reduction in rms SPL
- 9.9–13.7 dB reduction in $SEL_{ss}$ and $SEL_{cum}$

Noise attenuation systems offering comparable levels of protection will be used during bridge construction.

In order to detect acoustic-tagged Atlantic sturgeon[10] in the vicinity of pile-driving activities, [redacted] VEMCO VR2W acoustic monitoring receivers were deployed equidistant across the river and approximately in line with the pile-driving locations (one receiver on the [redacted] side of the river was not recovered; [redacted]. Each receiver had a detection range [redacted], within which the presence, identity (tag number) and residence time of individual tagged sturgeon were recorded by the receivers.

Over the course of the PIDP, 155 tagged Atlantic sturgeon were detected. Of these, 82 were detected during pile installation, which was defined to include not only actual pile-driving but other associated activities. Only two Atlantic sturgeon were detected in the shallow area on the western side of the river, indicating that Atlantic sturgeon were more likely to occur outside of the shallower areas in this part of the river.

Tag-detection data were used by the project team to assess: 1) avoidance of pile-driving noise by sturgeon, and 2) time spent by sturgeon in the vicinity of pile driving as it relates to the potential accumulation of sound energy and the onset of physiological effects. A more detailed description of the analyses is presented by AKRF and Popper (2012a, 2012b).

Based on available data on fish and noise, the project team hypothesized that detection time would be significantly less during active pile driving compared to the time period just prior to work beginning. This result was expected because avoidance of the area where increased underwater noise would be experienced was anticipated. To test this hypothesis, the amount of time spent by tagged Atlantic sturgeon within the detection area during active pile driving was compared to time spent in the area just prior to the work window. It was expected that pile-driving conducted using impact hammers would result in greater avoidance by tagged Atlantic sturgeon because of the higher sound pressures produced by the impact hammer compared to the vibratory hammer. Similarly, it was expected that large piles driven within the receiver detection areas (i.e., closer to detected sturgeon) would cause greater avoidance than small piles driven at distant locations outside of the detection areas (i.e., further from sturgeon).

[10] Atlantic and shortnose sturgeon are tagged by researchers authorized to conduct such tagging through issuance of permits pursuant to Section 10 of the ESA. The PIDP did not involve tagging any sturgeon but the receivers would detect sturgeon in the range of the receivers that were carrying appropriate tags. We do not have an estimate of the total number of sturgeon that are outfitted with compatible tags or the ratio of tagged to untagged sturgeon generally, or in the project area specifically.

When pile driving occurred at locations distant from the detection area, there was no difference in the amount of time spent by sturgeon in the detection area before vs. during active pile driving with the impact hammer ($P$=0.09) or with the vibratory hammer ($P$=0.22). This finding was expected since the noise resulting from the driving of [redacted] piles was not loud enough to elicit a behavioral response from sturgeon on the opposite side of the river. When pile driving occurred inside the receiver detection areas, tagged Atlantic sturgeon spent significantly less time in the area during active impact pile driving compared to the time period just prior to the work window ($P$=0.0024). However, there was no difference in the amount of time spent in the detection area before vs. during vibratory pile driving ($P$=0.79). These results indicate that tagged Atlantic sturgeon avoided the detection area when piles were being hammered with an impact hammer within the detection area, but not when pile driving was conducted using the vibratory hammer or when pile driving (impact or vibratory) occurred outside of the detection area.

Sturgeon could experience physiological effects if enough time is spent in proximity to sufficiently loud pile-driving activities. To examine the likelihood that sturgeon would be exposed to sufficient cumulative noise to reach the 187 dB re: 1 $\mu Pa^2 \cdot s$ $SEL_{cum}$ criterion for the onset of physiological effects, time spent by tagged sturgeon within range of the acoustic receiver was first estimated as the sum of detection times for individual sturgeon as recorded by the acoustic receivers. DEC raised concerns about using this approach since the actual time spent by sturgeon in the receiver detection area may be underestimated due to missed detections caused by tag interference when multiple tags broadcast simultaneously (i.e., code collision). Because of code collision, it is possible that a fish can go undetected for a short period of time despite being in range of the receiver. Although the manufacturer of the acoustic tags, VEMCO, did not believe it was necessary to account for code collision in this particular case because of the low number of co-occurring sturgeon, they concurred with the conservative approach that was implemented by AKRF and Popper (2012b) to account for potential missed detections resulting from code collision.

AKRF and Popper's (2012b) analysis indicated that the likelihood of Atlantic sturgeon reaching the noise level associated with the potential onset of physiological effects (i.e., 187 dB re: 1 $\mu Pa^2 \cdot s$ $SEL_{cum}$), even after accounting for potential tag interference caused by code collision, was extremely small during the PIDP. The results of this analysis indicate that for all but one sturgeon, the probability of experiencing physiological effects never exceeded 1%. This suggests that sturgeon moved away from the noise and avoided staying close enough to the pile driving for long enough to experience physiological effects. This determination used the FHWG criteria of 187 dB re: 1 $\mu Pa^2 \cdot s$ $SEL_{cum}$. When considering recent studies by Halvorsen et al. (2012), who demonstrated that the potential onset of physiological effects for even the smallest age-0 juvenile sturgeon may not occur until noise levels reach 207 dB re: 1 $\mu Pa^2 \cdot s$ $SEL_{cum}$, the potential for physiological effects would be even lower. Based on the results of the tag detection during the PIDP, it is reasonable to conclude that sturgeon will avoid areas in proximity of impact pile-driving operations and are highly unlikely to remain in the vicinity of pile driving long enough to reach the cumulative threshold associated with the potential onset of physiological effects. This is consistent with the analysis and assumptions presented in our 2012 Biological Opinion which assessed the potential for injury using the peak SPL criterion of 206 dB re 1 $\mu Pa$ (rather than the cumulative criterion of 187 dB re 1 $\mu Pa^2 \cdot s$).

### 7.2.3 *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.

#### *7.2.3.1 Noise Associated with Installation of Piles with a Vibratory Hammer*

Most, if not all, piles are expected to be at least partially installed with a vibratory hammer. For those piles that can be partially installed by vibratory hammer, FHWA predicts that, depending on the substrate type and location in the river, the [redacted] pile will be installed with a vibratory hammer. FHWA indicates that installation of the piles with a vibratory hammer is expected to produce acoustic footprints similar to driving sheet piles (163 dB re 1 μPa$^2$-s SEL$_{cum}$ [redacted] the driving of wood piles with an acoustic footprint of 150 dB re 1 μPa$^2$-s SEL$_{cum}$ [redacted] of the pile being driven (Jones and Stokes, 2009)). Installation of piles with a vibratory hammer will not result in peak noise levels greater than 206 dB re 1 μPa 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 RMS will be experienced [redacted] it is extremely unlikely that the behavior of any individual sturgeon would be affected by noise associated with the installation of piles with a vibratory hammer. Even if a sturgeon was within [redacted] 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 RMS 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 piles with a vibratory hammer will be insignificant and discountable. These conclusions are supported by the results of tagged sturgeon detection during the PIDP which indicated that sturgeon did not leave the detection area during vibratory pile driving.

#### *7.2.3.2 Noise Associated with the Drilling and Pinning of Piles*

While not currently planned, in some areas, pile installation may involve drilling a socket into rock to accommodate unanticipated geotechnical conditions. 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 drilling into rock to facilitate the installation of piles will be insignificant and discountable.

#### *7.2.3.3 Noise Associated with Installation of Piles by Impact Hammer*

All piles will be at least partially installed with impact hammers. These piles will be installed in two sections. The “bottom” section, which is installed first, is likely to be vibrated in (see above). 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 (based on PIDP

results), will be in place for all [redacted] piles installed with impact hammers. The use of an impact hammer will take 5-10 minutes for the trestle piles [redacted] and 20-60 minutes for each bridge pier pile [redacted], depending on the size and location of the pile. Pile driving will occur for up to twelve hours a day except in those rare occurrences when installation of a single pile must be completed and completion of that installation would extend the work window beyond 12 hours in a particular day.
In order to assess the potential effects of pile installation on shortnose and Atlantic sturgeon, the spatial extent of the hydroacoustic pattern generated by pile driving operations was evaluated using computer analyses that were refined by the PIDP results.

During the initial research and planning phases for this action, in-river acoustic footprints for pile diving of [redacted] piles were obtained by application of three sound transmission models (MONM, VSTACK, and FWRAM) developed by JASCO. (Use of [redacted] piles is no longer a part of the proposed action). Each of the 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 for the [redacted] piles 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: $1\mu Pa^2$-s. However, because actual noise measurements with attenuation devices in place were taken during the PIDP, these field measurements were considered to provide more accurate and representative data of proposed construction conditions than the modeled data for the [redacted] piles. [redacted] The monitoring results for the [redacted] piles are used as a surrogate for in-field monitoring results of the predict distances to the 150 dB re 1μPa RMS, 187dB re: $1\mu Pa^2$-s cSEL and 206 dB re 1μPa Peak isopleths from the [redacted] piles. These are considered highly conservative as the isopleths would be smaller for the smaller piles.

In-field measurements were made for the installation of [redacted] piles [redacted]. A single hydrophone was located [redacted] meters from the pile. Water depths were shallow, 5 to 10 feet. Measurements were used to estimate the distance from the pile to the 206 dB re 1μPa SPL peak, 187 dB re $1uPa^2$-s cSEL and 150 dB re 1μPa RMS SPL. The maximum recorded noise levels were used in the calculations. When estimating cSEL, the entirety of the impact pile installation period was used [redacted] These time periods are expected to correspond with the amount of impact pile driving necessary to install the [redacted] trestle piles; however, FHWA estimates it may take up to 20 minutes of driving to install the [redacted] bridge pier piles, so 20 minutes was used in those calculations. The practical spreading loss model was used. All calculations were carried out by AKRF and transmitted to NMFS by FHWA.

The table below provides estimates, based on in-river measurements of [redacted] piles, to the 150 dB re 1μPa RMS, 187dB re: $1\mu Pa^2$-s cSEL and 206 dB re 1μPa Peak isopleths. When calculating the distance to the 187dB re: $1\mu Pa^2$-s cSEL isopleth, FHWA used the maximum time expected for installation of that size pile (ranging from 5 to 60 minutes depending on size and type).

[redacted]

In addition to providing estimates of the size of the isopleths of interest for each pile type, FHWA has provided a table listing the number and type of each pile to be installed per week of construction as well as the amount of time expected for impact pile driving during that time period and the width of the 206 dB SPLpeak isopleth for that pile type [redacted] Various pile driving scenarios were used to generate the peak SPL levels for each day over the construction period. These tables take into account days when multiple piles are being driven and times when more than one pile is being driven at a time. This table incorporates the use of noise attenuation systems to provide a 10 dB reduction in sound [redacted] These systems were tested during the PIDP and provided the expected noise reduction; a method that provides at least a 10 dB reduction in underwater noise will be implemented during all pile driving [redacted] for bridge construction.

*7.2.3.3 Potential for Exposure to Underwater Noise*

Shortnose and Atlantic sturgeon are likely to be present in the Tappan Zee Reach throughout the construction period. If an individual fish occurs within an area(s) ensonified over Peak 206 dB re 1 µPa for a single strike or 187 dB re 1 $\mu Pa^2 \cdot s$ for accumulated energy ($SEL_{cum}$,) there is the potential for the onset of physiological effects. Fish are considered by NMFS to reach the onset of physiological effects either by being exposed to a single strike that reaches a specific $SPL_{peak}$ or by being exposed over time to a specific amount of accumulated sound energy, the $SEL_{cum}$. Unlike $SPL_{peak}$, $SEL_{cum}$ is a measure of prolonged exposure to pile driving sound over the duration of the pile driving operation, assuming the fish does not move away. As noted above, in order for the cSEL criteria to be relevant, the fish must stay in the ensonified area throughout the duration of the number of pile strikes factored into the noise estimate; for this action, [redacted] the number of pile strikes needed to install the pile with an impact hammer. In other words, there is the potential for physiological effects if a sturgeon is within [redacted] feet of a [redacted] pile for a single pile strike, or if a sturgeon stays within [redacted] feet of a [redacted] pile for the entire time it is being hammered with the impact hammer (a period of 22 to 126 minutes). For the [redacted] piles, a sturgeon would need to be within [redacted] feet for a single strike or stay within [redacted] feet of the pile for the entire time it is being hammered with the impact hammer (a period of at least 22 minutes and up to one hour).

We do not expect sturgeon to remain close enough to the piles being driven for a long enough time to experience prolonged exposure to intense pile driving noise. This is because we expect sturgeon to react behaviorally to the noise and move away from the source of the noise. This is supported by the results of the PIDP tag detection study which indicate that sturgeon were less likely to be present in the detection area when impact pile driving was occurring. We expect that any sturgeon close to piles when pile driving begins to react by leaving the area and expect that any sturgeon approaching the piles while pile driving is ongoing would move around the area. Because of this, it is extremely unlikely that a sturgeon would remain in the ensonified area over the duration of the installation of an entire pile. This is also supported by the PIDP results that indicate of the 82 tagged Atlantic sturgeon only one fish had a more than 1% probability experiencing physiological effects due to exposure to multiple pile strikes.

We have considered whether a sturgeon is likely to be able to swim far enough away from the pile being installed in time to avoid exposure to the full duration of pile installation. If a sturgeon was adjacent to a [redacted] pile at the onset of installation, it would need to swim [redacted] eet before the end of the 5 minute pile driving time, requiring a swim speed of approximately 0.4 feet per second (12 cm/s). [redacted]. FHWA predicts pile driving times of approximately one-hour; a sturgeon would need to swim at least 505 feet before the 60 minute pile driving time was completed, requiring a swim speed of approximately 0.14 feet per second (fps; 4.3 cm/s). Swim speeds necessary to move away from the [redacted] piles range from 0.07 – 0.28 fps.

Swimming speeds of fish are generally classified as sustained, prolonged, or burst. Sustained speeds are low and those which the fish can maintain for long periods (i.e., >200 min). They depend on aerobic metabolism, do not result in muscular fatigue, and are used in foraging and other routine activities. Prolonged speeds are moderate, of intermediate duration (i.e., 0.5–200 min), and use aerobic and anaerobic metabolism. Burst speeds are the highest attainable speeds, but can only be maintained for short periods (i.e., <0.5 min) due to accumulation of anaerobic metabolites and muscular fatigue. Higher prolonged and burst speeds are used in prey capture, short-term movements in fast current, and predator avoidance and, consequently, can be used to characterize ‘escape’ speeds. We would expect sturgeon swimming away from a loud noise (such as a pile being installed with an impact hammer) to start out at “burst” or “escape” speed and then slow down to “prolonged” speed when its burst speed duration had been exceeded.

A study examining movements of green sturgeon (101-153 cm TL) in San Francisco Bay (Kelly and Klimley 2011) reports an average swimming speed of 0.5-0.6 meters/second (1.6-2 fps) with a maximum recorded speed of 2.1 meters/second (7 fps). Studies examining the escape and critical speeds of white and lake sturgeon report that sturgeon can swim at short bursts (30 seconds or less) against velocities of 65-85 cm/s (2.1-2.7 fps) and that these species can swim for sustained time periods (greater than 200 minutes) against water velocities of 45 cm/s (1.4 fps). For prolonged periods (0.5 – 200 minutes), sturgeon could swim against water with velocities of 35-75 cm/s (1.1 – 2.4 fps) (see Peake 2006 in LeBreton et al. 2006).

Hoover *et al.* (2011) demonstrated the swimming performance of juvenile lake sturgeon and pallid sturgeon (12 – 17.3 cm FL) in laboratory evaluations. The authors compared swimming behaviors and abilities in water velocities ranging from 10 to 90 cm/second (0.33-3.0 fps). They report burst swim speeds of 40-70cm/s (1.3-2.3 fps), prolonged swimming at 15-70cm/s (0.5-1.5 fps) and sustained swimming at speeds of 10-45 cm/s (0.3-1.5 fps). Boysen and Hoover (2009) assessed the probability of entrainment of juvenile white sturgeon by evaluating swimming performance of young of the year fish (8-10 cm TL). The authors report escape speeds of 40-45 cm/s. Clarke (2011) reports on swim tunnel performance tests conducted on juvenile and subadult Atlantic, white and lake sturgeon. He concludes that burst swim speed is approximately 65 cm/s and prolonged swim speed is 45 cm/s.

Assuming that the sturgeon in the action area have a swimming ability equal to those tested in the studies summarized above, we expect all shortnose and Atlantic sturgeon in the action area to have a prolonged swim speed of at least 1.1 fps (35 cm/s) and an escape or burst speed of at least 1.4 fps (45 cm/s). Sturgeon are expected to be able sustain their prolonged swim speed for up to 200 minutes without muscle fatigue. To move away from a pile being installed in sufficient time to avoid accumulating enough energy to result in injury, a sturgeon would need to be swimming at 0.14-0.28 fps for a period of less than 60 minutes. This is a fraction of the sustained swim speeds reported above, and is less than the time that an individual is expected to be able to sustain the prolonged swim speed; therefore, we expect all sturgeon in the action area to be able to readily swim away from the ensonified area in time to avoid injury.

The cSEL 187 dB re 1µPa$^2$-s area never occupies the entire width of the river; therefore, there is no danger that a fish would not be able to “escape” from the area while pile driving is ongoing. Because we do not expect sturgeon to remain close enough to a pile being installed with an impact hammer for long enough to accumulate enough energy to be injured, we have determined that when assessing the potential for physiological impacts, the 206 dB re 1µPa peak criteria is more appropriate. This represents an instantaneous, single strike, noise level. Thus, considering the area where this noise level will be experienced would account for fish that were in the area when pile driving started or were temporarily present in the area.

To minimize the potential for sturgeon to be close enough to the piles to be injured after a single strike, a “ramp up” procedure will be used. This method involves starting pile driving at a low energy designed to cause fish to move away from the pile before driving at maximum energy begins. Some anecdotal evidence exists to support this idea. For example, during the construction of the Woodrow Wilson Bridge over the Potomac River, there is evidence that tapping the pile with lower energy for the first few strikes may cause fish to move away from the piles before full operations begin (FHWA 2003). Reports from the Woodrow Wilson Bridge construction indicated that in some cases this kind of ramp-up procedure substantially decreased mortality; however, these findings were anecdotal and were not part of scientifically controlled studies. This "ramp up" or "soft start" method is also used to minimize potential exposure of marine animals to seismic and other noisy survey methods. The bridge replacement project will use a soft start method for all impact pile driving.

*7.2.3.4 Estimating the Number of Sturgeon Likely to be Exposed to Increased Underwater Noise*

In order to be exposed to increased underwater noise that could result in physiological effects, a sturgeon will need to be in relatively close proximity of the pile driving [redacted]. Available data for the Hudson River indicates that shortnose and Atlantic sturgeon are likely to be in the Tappan Zee area year round. However, there is limited information on the number or density of these species (e.g., estimate of shortnose or Atlantic sturgeon per acre) likely to be in the area at any given time or even on an annual basis.

In the 2012 BA, FHWA used the encounter rate of shortnose sturgeon in a 1-year gillnet sampling study to generate fish abundance estimates. From June 2007 – May 2008, 476 gillnets were deployed just upstream of the existing Tappan Zee Bridge (and within the area where the bridge replacement will occur) for a total sampling time of 647 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 project area is 0.02 sturgeon encountered per hour of sampling. The gillnets used for this study consisted of five panels, one 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 areaare 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. FHWA then used this encounter rate to calculate the number of shortnose sturgeon that are likely to be present in an area of a given size.

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. 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 numbers to be scaled to a particular sized area; in this case, (that is, the width of the isopleth). As an example, if the isopleth under consideration extended [redacted] feet from the pile being driven that would be equivalent to 20 gill nets. Using this method, and considering an encounter rate of 0.03 sturgeon per net per hour, a [redacted] a [redacted] pile installation, you could estimate that 1.2 shortnose sturgeon would pass through the ensonfied area during the pile installation.

[redacted] From these distances the diameter of the ensonified area is calculated by doubling the radius. Based on the calculated diameters of the ensonified area and the size, number and timing of piles to be driven, FHWA uses the sturgeon encounter method to calculate the number of shortnose sturgeon potentially exposed to peak noise of 206 dB re 1uPa; this results in an estimate of up to 37 shortnose sturgeon. [redacted] This estimate considers all piles installed with an impact hammer, including the temporary trestle piles and the piles installed for the second PIDP, as well as the permanent bridge piles.

Based on in-water acoustic monitoring of the installation of [redacted] permanent piles (installed between October 19 and December 16), up to two shortnose sturgeon were exposed to peak noise of 206 dB re 1uPa during this period (FHWA 2014, First Tappan Zee Bridge Monthly Pile Driving Report). This is consistent with the amount of take anticipated based on acoustic modeling [redacted]

Acoustic modeling of all piles installed with an impact hammer through February 22, 2014 (considered the end of 2014 week 8) indicates that 10 shortnose sturgeon were exposed to peak noise of 206 dB re 1uPa during this period [redacted] Therefore, impact pile installation to date has resulted in the exposure of up to ten shortnose and ten Atlantic sturgeon to peak noise of 206 dB re 1uPa; we expect these sturgeon experienced minor injury.

No Atlantic sturgeon were captured during the survey; thus, we cannot generate an encounter rate for Atlantic sturgeon. As noted above, 155 individual tagged Atlantic sturgeon were detected by the receivers deployed during the PIDP in April and May 2012. If we knew the ratio of tagged to untagged sturgeon we could generate a density estimate which could allow us to calculate the number of Atlantic sturgeon likely to be exposed to increased underwater noise. However, we know neither the total number of Atlantic sturgeon with tags that were active in April and May 2012 or the total number of Atlantic sturgeon that were in the Hudson River at that time. Therefore, we cannot generate a reliable ratio of tagged to untagged Atlantic sturgeon and cannot use this to generate a density estimate.

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 NYSDEC 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 Hudson River are considerably lower than numbers of shortnose sturgeon.

In the 2012 BA, FHWA presented a methodology to estimate the number of Atlantic sturgeon likely to be exposed to noise that would result in physiological effects. This method aimed to determine the differential gear selectivity for shortnose versus Atlantic sturgeon by using the ratio of shortnose to Atlantic captured in sampling studies to determine how many fewer Atlantic sturgeon than shortnose sturgeon we anticipate in the action area. The first step of the analysis was to compare the size distribution of shortnose and Atlantic sturgeon collected by the Fall Shoals sampling gear (3-m beam trawl) in an extended data set. Based on the similar size distribution of Atlantic (51 – 952 mm total length (TL)) and shortnose sturgeon (75 – 928 mm TL) collected in the Fall Shoals Program between 1998-2007, it was assumed that gear efficiency is similar for both species within the size range collected (i.e., <1,000 mm TL). In the BA, FHWA considers Atlantic sturgeon <1,000 mm to be resident riverine juveniles; however, Atlantic sturgeon are considered subadults once they reach a size of 500mm and may begin making coastal migrations out of their natal river at that time; therefore, Atlantic sturgeon in the Hudson River that are larger than 500 mm, but less than 1,000 mm may originate from rivers other than the Hudson. FHWA explains that because of the lack of population-size estimates for Atlantic sturgeon and the similarities in body size and overlapping habitat use between both sturgeon species during the riverine occupancy (Bain 1997), the population estimate developed by Bain et al. (1998, 2007) for shortnose sturgeon was used to develop a gear-efficiency correction factor for the 3-m beam trawl used to sample sturgeon abundance as part of the Utilities fish sampling program. The population estimate of 61,057 from Bain et al. (1998, 2007) is considered an accurate estimate for shortnose sturgeon as it is based on mark-recapture studies in which the size of the sample population (i.e., tagged fish) is known. The standing crop estimate for shortnose sturgeon using Fall Shoals data (unadjusted for gear efficiency) from the same time period (1994-1997) as the Bain studies were performed was 27,534 fish. The percentage of adult shortnose sturgeon (≥550-mm TL) represented by Bain *et al.*'s (1998, 2007) estimate was 93%, with the remaining 7% represented by juveniles (<550-mm TL). Similarly, 90% of the shortnose sturgeon collected during the Fall Shoals survey between 1994-1997 were adults, with the remaining 10% in the size range of juveniles (<550 mm TL).

Gear efficiency was then estimated for both size classes of shortnose sturgeon (<550-mm TL and ≥550-mm TL) by dividing the juvenile and adult proportions of the Fall Shoals standing crop estimate (2,753 and 24,781, respectively) by the same proportions of the Bain et al. (1997) population estimate (4,274 and 56,783, respectively). The resulting gear-efficiency correction factors were 64% for sturgeon <550-mm TL and 44% for sturgeon between 550-1,000-mm TL.

FHWA's standing crop estimate (unadjusted for gear efficiency) for "riverine juvenile Atlantic sturgeon (<1,000-mm TL)" (see note above regarding FHWA's definition of juveniles) was calculated using volume-corrected Atlantic sturgeon abundances from 1998-2007 Fall Shoals data stratified by sampling week, habitat (shoal, channel, bottom) and Utilities-survey river segment (e.g., Tappan Zee, Battery, Hyde Park, etc.). Abundances were interpolated for weeks that were not sampled. Weekly average standing crop was then calculated for each of the 52 calendar weeks and the maximum weekly average of 12,142 juvenile Atlantic sturgeon was calculated as the standing crop estimate for this time period and size range.

An examination of the Fall Shoals dataset revealed that 30% of the 233 Atlantic sturgeon collected in the Hudson River between 1998 and 2007 were ≥550-mm TL and the remaining 70% were <550-mm TL. These percentages were used to parse the standing crop estimate of 12,142 sturgeon into size classes which were then corrected for gear efficiency to yield an estimate of 13,708 juvenile Atlantic sturgeon (<550-mm TL) and 8,280 juvenile Atlantic sturgeon (≥550-mm TL) in the river (as noted above, we consider fish of this size to not be juveniles, but to be subadults). Based on the size of Atlantic sturgeon in this dataset (51 – 952-mm TL), this population of 21,988 Atlantic sturgeon was considered to consist of a number of age classes, including young of year, 1 and 2 year old fish, and fish 3 years old and possibly older (Bain 1997; Peterson et al. 2000).

To estimate the number of Atlantic sturgeon that would be exposed to noise levels that could result in physiological effects, mean weekly Atlantic sturgeon densities were then applied to the water volumes ensonified by the 206 dB re 1uPa peak isopleths during each week of the proposed construction schedule to estimate the total number of fish expected to be potentially affected by pile-driving activities on a weekly basis over the course of bridge construction. The approach followed the proposed construction schedule and accounted for the various combinations of pile sizes that will be driven simultaneously, their location along the span, and their depth within the River. Fish numbers were expressed by FHWA in terms of the "Hudson River juvenile population of Atlantic sturgeon".

Upper and lower bounds for the number of fish exposed to the ensonified area were estimated by first assuming that the Hudson River population exists in a closed system (i.e., there is no immigration or emigration). Under this assumption, the same individual fish can be observed multiple times and the number of fish vulnerable to noise impacts cannot exceed the maximum weekly average number of fish observed.

Therefore, the lower bounds were calculated as:

$$\text{Sturgeon}_{max} / \text{SC}_{max} \text{ X } 100$$

where,
Sturgeon $_{max}$ = the maximum weekly number of sturgeon within the isopleths, and
SC $_{max}$ = the maximum weekly average standing crop of the Hudson River.

Because FHWA considered that fish <1,000 mm would be Hudson River origin fish and in fact, fish >500mm could be migrants from other river systems, the assumption built into this model to generate the lower bounds (i.e., that the Hudson River is a closed system), is not a reasonable assumption.

To estimate the upper bounds, it was assumed that the Hudson River population exists in an open system with juvenile Atlantic sturgeon moving throughout the River. In this case, sturgeon are never observed more than once and every sturgeon observed within the project area is counted as a different individual. Under these assumptions, the number of juvenile sturgeon within the ensonified area each week was summed across all weeks and divided by the number of weeks of pile driving. This average weekly number of sturgeon was then multiplied by 52 weeks in a year to determine the number of affected fish during an average construction year.

Therefore, the upper bounds were calculated as:

$$(\sum \text{Sturgeon}_{weekly} / \text{n}_{weeks}) * 52 / \text{SC}_{max} \text{ X } 100$$

where,
Sturgeon $_{weekly}$ = the weekly number of sturgeon within the isopleths, and
n $_{weeks}$ = the number of weeks of pile driving during construction.

Using this methodology, FHWA determined that no more than one juvenile Atlantic sturgeon would be exposed to noise of a peak 206 dB re 1uPa. As noted above, this estimate was generated in the 2012 BA [redacted] However, even when considering the upper bounds of this model, while the model assumes an "open system" with sturgeon moving throughout the River, it does not appear that the model accounts for the potential for Atlantic sturgeon of this size class to leave the river or to enter the river from other systems. Additionally, we cannot validate the assumptions made regarding gear selectivity for shortnose vs. Atlantic sturgeon. For example, we do not know if there are behavioral differences that make it or more or less likely to capture a shortnose sturgeon versus an Atlantic sturgeon of the same size in the same gear. Because of these factors, and because we cannot validate other model parameters, it is difficult to determine the validity of these estimates.

FHWA also estimated the number of adult Atlantic sturgeon that would be exposed to noise that could result in physiological effects. Because of their large size, adult sturgeon are able to avoid collection by the beam trawl during Fall Shoals sampling. Therefore, the number of adults potentially affected by pile-driving noise was estimated as a function of the probability of their exposure to noise. FHWA considered that approximately 288 adult Atlantic sturgeon would enter the Hudson River to spawn that year and that these would be the only adults in the river. This is likely to be an underestimate of the number of adults in the river because: (1) non-spawning adults that originate from the Hudson River as well as from other rivers are known to occur within rivers (as evidenced by genetic sampling (Fox, unpublished data 2011)); and, (2) the number of spawning adults in the Hudson River in a given year could be as high as 730 individuals. This is based on the estimated adult population of 596 males, that spawn every 1-5 years and 267 females that spawn every 2-5 years. FHWA considered only that approximately 1/3 of the total number of adults (863) would return to the river to spawn each year. FHWA also only considered that each sturgeon would pass through the project area twice, once while moving upstream to spawn and once while moving downstream to spawn. While these types of singular directed movements are possible, tracking data suggests that sturgeon may make many up and down movements during the spring. Thus, this methodology likely results in an underestimate of the number of adult Atlantic sturgeon that would be exposed to pile driving noise.

While we cannot rely on the estimates provided by FHWA for the number of juvenile or adult Atlantic sturgeon likely to be exposed to noise levels of 206 dB re 1 µPa peak, all available data indicates that there are fewer Atlantic sturgeon in the project area than shortnose sturgeon and we have an estimate of the number of shortnose sturgeon likely to be exposed to noise levels of 206 dB re 1 µPa peak, we can produce an estimate of the maximum number of Atlantic sturgeon we expected to be exposed to noise levels of 206 dB re 1 µPa peak. We do not expect that Atlantic sturgeon use this area of the river more frequently than shortnose sturgeon (i.e., we do not expect more Atlantic sturgeon in the area than shortnose sturgeon) and we expect that because of similar morphology, we expect their hearing and behavioral responses to sound to be similar. Based on the calculations for shortnose sturgeon, we anticipate that the number of Atlantic sturgeon that may be exposed to noise levels of 206 dB re 1 µPa peak and therefore, the number that may experience physiological effects, would be no more than 37, the same maximum estimated for shortnose sturgeon.

*Estimate of the Number of Shortnose sturgeon that will experience Physiological Effects*

[redacted] The analysis assumed a 10dB reduction in noise was achieved by the implementation of noise attenuation measures for [redacted] piles. Testing during the PIDP indicates that this 10 dB reduction will be achieved using the proposed attenuation measures. This analysis incorporates the best estimate of pile driving scenarios throughout the construction period, including multiple piles being driven at one time. The estimates round up any calculation resulting in more than 0.05 of a fish to a whole fish. Using the method explained above, FHWA estimates the number of shortnose sturgeon potentially exposed to underwater noise which may cause physiological effects (i.e., peak 206 dB re 1µPa) at 37; considering the pile driving that has been completed to date, we expect 10 of these exposures to already have happened.

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. 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. 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 and reduce the potential for exposure to noise levels that would be potentially mortal. 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 only way that a shortnose sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique and the expected behavioral response of moving away from the piles being installed, this situation is likely to be very rare; however, given the number of piles to be installed and the duration over which pile driving will occur, it is possible that this unexpected event could occur. However, because we expect it to be very rare, we expect that no more than one shortnose sturgeon is likely to suffer major injury or die as a result of exposure to pile driving noise. Effects on behavior are discussed below. It is important to note that during the PIDP, where seven test piles were installed with impact hammers, FHWA conducted monitoring designed to detect any stunned, injured or dead sturgeon during and following pile driving. As noted above, during the PIDP 155 tagged Atlantic sturgeon were recorded in the project area; no injured or dead sturgeon were observed during the PIDP monitoring. This supports the conclusions reached here, that serious injury and mortality will be rare. Monitoring for injured or dead fish also occurred during the 2013 PIDP and the installation of all permanent piles; no injured or dead sturgeon have been observed during this monitoring to date.

Pile driving will occur year round; therefore the Atlantic sturgeon exposed to pile driving noise are expected to be juveniles, subadults and adults. However, because the potential for mortal injury due to noise exposure decreases with fish size, and because adult Atlantic sturgeon are very large (at least 1,500 mm (approximately 5 feet in length), it is unlikely that the one fish that we expect to experience serious injury or mortality would be an adult. Based on the mixed-stock analysis, we expect of the 37 Atlantic sturgeon that could experience physiological effects, 34 (92%) would be from the New York Bight DPS (juveniles, subadults or adults), two (6%)from the Gulf of Maine DPS (subadults or adults), and one (2%) from the Chesapeake Bay DPS (subadults or adults). Based on the pile driving that has been completed to date, ten Atlantic sturgeon have already been exposed to peak noise of 206 dB re 1uPa; we expect that 9 of these were from the NYB DPS and 1 from either the Gulf of Maine or Chesapeake Bay DPS.

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. 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. 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 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 and reduce the potential for exposure to noise levels that would be potentially mortal. 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. 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 sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that an Atlantic sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique and the expected behavioral response of moving away from the piles being installed, this situation is likely to be very rare; however, given the number of piles to be installed and the duration over which pile driving will occur, it is possible that this unexpected event could occur. However, because we expect it to be very rare, we expect that no more than one Atlantic sturgeon is likely to suffer major injury or die as a result of exposure to pile driving noise. It is most likely that the one fish that may be mortally injured or killed would originate from the New York Bight DPS. However, because Atlantic sturgeon from the Chesapeake Bay and Gulf of Maine DPSs are also present in the area, it is possible that the fish that dies could originate from any of the three DPSs. 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 RMS will be experienced and the duration of time that those underwater noise levels could be experienced.

Depending on the pile size being driven, the 150 dB re 1 μPa RMS isopleth (radius) would extend from 332 to 886 feet from the pile being driven. Shortnose and Atlantic sturgeon in the area where piles are being installed are likely to be foraging (in areas where suitable forage is present), resting, or migrating to upriver or downriver areas. The action area is not known to be an overwintering area or a spawning or nursery site for either species. We consider two scenarios here; (1) sturgeon that are near the pile being installed and must swim away from the pile to “escape” the area where noise is greater than 150 dB re 1µPa RMS; and, (2) sturgeon that are outside of the area where noise is greater than 150 dB re 1µPa RMS at the onset of pile driving but then would avoid this area when pile driving was ongoing.

In the first scenario, sturgeon exposed to noise greater than 150 dB re 1µPa RMS are expected to have their foraging, resting or migrating behaviors disrupted as they move away from the ensonified area. Even at a slow prolonged speed of 1.1 fps, all sturgeon would be able to swim out of the area where noise is 150 dB re 1uPa RMS within 30 minutes (in the worst case, swimming through the longest cross section of 1,772 feet). Thus, any disruption to normal behaviors would last for no longer than 30 minutes. . Foraging is expected to resume as soon as a sturgeon leaves the area. Resting and migrating would also continue as soon as the individual had moved away from the disturbing level of noise. It is unlikely that a short-term (in the worst case no more than 30 minutes, and generally much shorter) disruption of foraging, resting or migrating would have any impact on the health of any individual sturgeon. Also, because we expect these movements to occur at normal prolonged swim speeds, we do not expect there to be any decrease in fitness or other negative consequence.

The Hudson River at the project site is approximately 14,700 feet wide (15,840 feet). At all times pile driving will be conducted in a way that ensures at least 5,000 feet of river width with noise levels less than 150 dB re 1uPa RMS, with no segment of quiet area less than 1,500 feet wide. Therefore, it is likely that any sturgeon that was not close to the pile at the time installation began, would be able to completely avoid the area where noise was greater than 150 dB re 1uPa RMS Assuming the worst case behaviorally, that sturgeon would avoid an area with underwater noise greater than 150 dB re 1 µPa, there would still always be a significant area where fish could pass through unimpeded. Additionally, pile driving will only occur for 12 hours per day, five days per week. No pile driving will occur on the weekends. Over the course of the five-year project, pile driving will be ongoing for approximately 7% of the time; thus, the time period when sturgeon would expect to react behaviorally to pile driving noise is relatively small. In the worst case, fish would avoid the ensonfied area for the entirety of the pile driving period; however, pile driving will never occur for more than 12 hours a day and the 150 dB re 1uPa RMS isopleth never extends across the entirety of the river; therefore we anticipate that there will be a zone of passage available for sturgeon through the project area at all times. Also, because spawning does not occur in the project area, there is no potential for noise to disrupt spawning.

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 a portion of the river width where noise levels would be less than 150 dB re 1 µPa RMS and that the size of the area to be avoided does not have a radius of more than 886 feet, any changes in movements would be limited to temporary avoidance of a small area, 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 where noise will be low enough that no behavioral response is anticipated (and therefore sturgeon could freely migrate through without any behavioral change) and the small size of the area to be avoided (radius of 886 feet in an area where the river width is more than 14,000 feet), 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 pile installation will preclude any shortnose or Atlantic sturgeon from completing any normal 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, with rare exception, we anticipate that the effects of this 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 37 or fewer shortnose sturgeon and 37 or fewer than Atlantic sturgeon over the duration of the bridge replacement. Based on the work completed to date, we expect that 10 shortnose sturgeon and 10 Atlantic sturgeon have already experienced physiological impacts (likely minor injuries) due to exposure to impact pile driving noise. Therefore, we anticipate the exposure of 27 additional shortnose sturgeon and 27 additional Atlantic sturgeon to noise that may result in physiological impacts over the remaining duration of pile installation. We anticipate the serious injury or mortality of no more than one shortnose sturgeon and no more than one Atlantic sturgeon.

## 7.4 Impacts of Vessel Traffic

### *7.4.1 Potential for Vessel Strike*

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 two suspected ship strike mortalities. On November 5, 2008, in the

Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20 foot) 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 bridge construction project would increase the risk of interactions between shortnose sturgeon and ships in the Hudson River generally.

As noted in the 2007 Status Review and the final listing 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.). Large vessels have been implicated because of their deep draft [up to 12.2-13.7 m (40-45 feet)] relative to smaller vessels [<4.5 m (15 feet)], which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Smaller vessels and those with relatively shallow drafts provide more clearance with the river bottom and reduce the probability of vessel-strikes. Because the construction vessels (tug boats, barge crane, hopper scow) have relatively shallow drafts, the chances of vessel-related mortalities are expected to be low. The maximum allowable draft of any of the construction vessels will be 3.2 to 3.6 m (10.5 to 12 feet), however, under typical operating conditions, vessels will draft 2.1 to 2.4 m (7 to 8 ft), providing 1.8-2.4 m (6-7 feet) of clearance with the bottom at all times. Maximum allowable drafts will only occur under full load and while turning. Under working conditions, stationary tug boats will maintain 1.8 m (6 feet) clearance between the prop and the bottom and will only infrequently approach 1.1 m (3.5 feet) clearance.

Tug boats will be used to tow barges to the dredged material offloading site downriver. Approximately six trips will be made each day that dredging occurs with the vessels transiting at 2-4 knots downriver while loaded and 4-6 knots back upstream when full. The shallow draft and slow speed of these vessels is similar to the construction vessels discussed above. The increased vessel traffic associated with the Tappan Zee Bridge replacement is not expected to result in direct interactions with sturgeon, because the life stages present in this reach of the river tend to occupy the bottom meter of the water column over fine-grained substrates in the deepest water areas and would be below the draft of the vessels involved.

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 bridge replacement project 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 bridge replacement project is extremely small.

Given the small increase in vessel traffic, the slow speeds that these vessels are expected to operate at, and the navigational clearance in the area, it is unlikely that there would be any detectable increase in the risk of vessel strike. As such, effects to shortnose and Atlantic sturgeon from the increase in vessel traffic are likely to be discountable.

### *7.4.2 Noise Associated with Vessel Movements*

Another potential impact associated with increased vessel traffic is radiated noise. Fish in the action area experience an acoustic environment that is generally highly energetic under "normal" conditions. The sound levels lower in the estuary result from the high volume of commercial shipping traffic within the tidal Hudson and New York Harbor, and these do not appear to affect the behavior or migration of sturgeon that bypass this very noisy region each year. While noise levels resulting from shipping in the estuary are not known, it is possible to get a first approximation based upon results of other studies which indicate that sound levels due to radiated vessel noise would be below thresholds for the onset of injury to fish (Wursig *et al.*

2002). Furthermore, because of the comparatively poor hearing ability of sturgeon (Lovell *et al.* 2005; Meyer *et al.* 2010, 2012), it is likely that many of the sounds which are audible to most species, are not audible to sturgeon.

Because these representative values of radiated vessel noise are well below the peak SEL of 206 dB re 1 μPa criterion established for pile driving, and because the Hudson River is subject to substantial commercial and recreational vessel noise under "normal" conditions, any incremental increase sound associated with vessel traffic related to bridge construction is not expected to affect sturgeon.

### 7.5 Loss of Benthic Resources

Dredging will remove benthic organisms that are immobile or have limited mobility from the access channel. Bed leveling will also disturb the benthos but because the bed leveler will be used after dredging has occurred, the bottom will already have been disturbed. Use of the bed leveler does not result in any additional loss of benthic organisms.

Dredging will remove benthic macroinvertebrates, including oyster beds. Approximately 0.56 $km^2$ (139 acres) of bottom habitat, all open water benthic habitat, would be dredged over the two year period. In addition, the trench would be armored following dredging and the benthic habitat within the dredge zone which was primarily soft sediment would be changed to a substrate of sand and gravel. Since armoring would occur up to 6.1 m (20 feet) of the side slope, total acreage of hard bottom would be approximately 0.43 $km^2$ (107 acres). The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. Modeling indicated that the rate of this transformation would begin at approximately one foot per year, likely decreasing as the bed nears it natural pre-dredged elevation. Other studies indicate that deposition rates in this portion of the river can vary widely depending on seasonal events such as storm events and freshets, and may be somewhat slower than predicted by the modeling. It is expected that the sand and gravel will, over time, naturally return to soft sediment as new material is deposited in the access channel area. Since much of the benthic community exists in the upper 10 cm of sediment as demonstrated from benthic samples taken throughout the Hudson River (Versar 2003), benthic recovery should begin quickly, particularly in the soft bottom sediments.

Recovery rates of benthic macroinvertebrate communities following dredging range from only a few weeks or months to a few years, depending upon the type of project, the type of bottom material, the physical characteristics of the environment and the timing of disturbance (Hirsch *et al.* 1978, LaSalle *et al.* 1991). In a two year study in the lower Hudson River, Bain *et al.* (2006) reported that within a few months following dredging, the fish and benthic communities at a dredged location were no different from seven nearby sites that had not been dredged. The results of monitoring did not indicate a lasting effect at the dredged site. This suggests that as material is redeposited in the access channel area, it will be settled by macroinvertebrates.

The temporary loss of the access channel area for foraging would represent a minor fraction of similar available habitat throughout the Tappan Zee region (less than 1.2%) as defined by the Hudson River Utilities (RM 24-33), and an even smaller percentage of the riverwide benthic area (less than 0.2%). The majority of the bottom habitat (and associated benthic macroinvertebrates within the area impacted) is the soft sediment community which dominates the Upper New York Harbor and Hudson River. Deposition within the dredged channel is predicted to occur at a rate of about one foot per year (see Appendix E of DEIS for deposition rate calculations) or less. Recolonization by benthic organisms adapted to softer sediments could be expected to begin within a few months after completion of in-water activities in any given area. Prior to the deposition of sufficient sediment to support a soft substrate benthic invertebrate community, some recolonization of the gravel armor material would be expected occur. Organisms within the nearby gravel substrate located within the main channel (NYSDEC benthic mapper http://www.dec.ny.gov/lands/33596.html, and Nitsche *et al.* 2007) would serve as a source of organisms to colonize the gravel capping material until the soft sediment is of a sufficient depth to be colonized by soft substrate organisms. Once in-water activities are completed, the dredged channels would be restored over time to their original elevations by action of natural sedimentation, and the river's benthic community would recolonize those areas as well.

In summary, with the exception of approximately 8.1 acres of oyster beds that may be permanently lost where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the soft bottom habitat of the Tappan Zee region (less than 1.2%) and the Hudson River Estuary (less than 0.2%). Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations. As noted above, once in-water activities are completed, the dredged channels would be restored over time to their original elevations and the river's benthic community would recolonize those areas. As the area returns to soft sediment and is recolonized by benthic invertebrates, sturgeon will regain any lost foraging habitat.

Dredging would remove [redacted] oyster beds, some or all of which may be permanently lost due to dredging and armoring of the bottom. Oyster beds were mapped using side scan sonar imagery approximately two miles north and south of the existing bridge from depths of 2.4 to 9.1 m (8 to 30 feet). Seven potential oyster beds were identified south of the bridge and six potential beds to the north (see Appendix E-3 of the DEIS for a description of each of the beds). During the subsequent grab sample program all identified oyster beds except one were confirmed to contain at least some live organisms with beds exhibiting differences in terms of oyster density, amount of shell hash, gravel, or sandstone fragments, etc. It is likely that mitigation for loss of the oyster beds will be implemented; however, no details on the extent or likely success of oyster mitigation requirements (e.g. creation of new oyster beds, augmentation of existing beds) are available at this time. Neither Atlantic or shortnose sturgeon are known to feed on oysters (see Haley *et al.* 1996 and Haley 1999 for discussion of diets in the Hudson River). Studies on foraging Atlantic sturgeon indicate that their benthic invertebrate prey are typically found in fine-grained silt-clay sediments (Hatin *et al.* 2002, 2007). Studies carried out on foraging Atlantic and shortnose sturgeon in the Hudson River indicate that significantly more shortnose and Atlantic sturgeon were collected over silt substrate as compared to sand or gravel. Ninety-two percent of collected shortnose were on silt substrate with none on gravel substrate. Similarly, 96% of Atlantic sturgeon were collected over silt substrate, with none collected over gravel substrate. Based on this, the loss of hard bottom substrate provided by the oyster beds is not likely to affect foraging shortnose sturgeon.

In summary, with the exception of oyster beds that may be permanently lost, where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the Hudson River Estuary and its soft bottom habitat. Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations. Because similar habitat is available nearby and because sturgeon are highly mobile and move throughout the estuary and river during the summer months while foraging, any effects on sturgeon movements are likely to be within their normal foraging behaviors. The very small amount of habitat lost, and the temporary nature of this loss, makes it extremely unlikely that the ability of sturgeon to find appropriate forage in sufficient quantities would be reduced.

## 7.6 Effects of Increased Turbidity and Suspended Sediment

Several activities will result in increases in turbidity and/or suspended sediment including dredging, bed leveling, depositing sand and gravel to armor the access channel and the installation of cofferdams and piles. 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 Hurricane Irene in 2011 when the extremely high turbidity episode lasted several weeks.

Dredging operations cause sediment to be suspended in the water column. This results in a sediment plume in the river, typically present from the dredge site and decreasing in concentration as sediment falls out of the water column as distance increases from the dredge site. Dredging will occur for approximately 90 days, with dredging occurring up to 24 hours a day depending on the particular contractor, weather and other activities ongoing in the river.

Several studies have been conducted on water quality changes associated with bucket dredge operations. In 2001, Normandeau Associates monitored water quality during dredging operations at BIW. Pre-dredge total suspended solids (TSS) levels ranged from 20-49mg/L. The maximum observed TSS levels during and after dredging with a mechanical dredge was 55mg/L. This level was recorded during an ebb tide, [redacted] feet from the dredge. Additional monitoring was conducted during dredging in 2002. Pre-dredge turbidity ranged from 5.0-7.9 NTU with TSS values ranging from 12 -18 mg/L. During dredging, TSS ranged from 24 to 43 mg/L. While increased turbidity was experienced at a distance of 150 feet from the dredge, the highest concentrations were limited to the area within 50 feet of the dredge.

Monitoring of twelve mechanical dredge operations in the Delaware River (Burton 1993) in 1992 indicated that sediment plumes fully dissipated [redacted] from the dredge area. The Delaware River study also indicated that mechanical dredging does not alter turbidity or dissolved oxygen to a biologically significant degree and analysis did not reveal a consistent trend of higher turbidity and lower dissolved oxygen within the sediment plume.

Neither the BIW study or the Delaware River study employed a closed environmental bucket dredge; this type of dredge is designed to release even less material into the water column. A study carried out in Boston Harbor monitored TSS levels during dredging with a closed environmental dredge in an area where depths ranged tidally from 38 to 48 feet. The highest TSS level observed with the environmental dredge was 112 mg/L (ACOE 2001).

Hydrodynamic modeling conducted for the Tappan Zee project and discussed in the DEIS (FHWA 2012) indicated that on flood and ebb tides, concentrations of suspended sediment 10 mg/L above ambient conditions may extend in a relatively thin band [redacted] feet from the dredges, while concentrations of 5 mg/L may extend a greater distance. These changes are considered well within the natural variation that has been observed within the Hudson River. For example, during the sampling conducted for the project, TSS concentrations ranged from 13 to 111 mg/L. Data recorded at Poughkeepsie indicated that during higher freshwater flow periods the difference between suspended sediment concentrations can vary by 20 to 40 mg/L.

FHWA has determined that suspended sediment concentrations resulting from bed levelling or bottom profiling will be similar to those resulting from dredging (i.e., up to 112 mg/l adjacent to the dredge bucket and dissipating to less than 10mg/L within 2,000 feet). The beam will only be dropped 6” into the sediment during any one pass through the area in order to minimize the amount of sediment suspended during sediment profiling.

A layer of sand and gravel (referred to as “armor”) will be placed at the bottom of the access channel following dredging. This is being done to minimize the scouring of the bottom from propellers on working tugboats. Sand and gravel will be deposited on the bottom with barge-mounted cranes. The thickness of the deposit will be two feet; resulting depths in the access channel will be 16 feet below MLLW. Deposition of this material will result in increases in suspended sediment and turbidity and could bury benthic resources.

Placement of the sand/gravel armoring material within the dredged area has the potential to result in sediment resuspension when the capping material is deposited upon the sediment. Results of monitoring conducted during placement of granular capping material on soft sediment indicated that resuspended sediment plumes were due to fines washed of the sand cap material and not due to resuspension of bottom sediment as the capping material was put in place (USACE 2005a). Measures would be implemented during placement of the sand layer of the armoring to minimize resuspension of the newly exposed sediment. These measures are the same type of measures that have been demonstrated to successfully cap contaminated sediment with minimal mixing of the cap with contaminated sediment (Palermo *et al.* 2011), and for the capping of subaqueous dredged material (Palermo *et al.* 1998). They include both mechanical (dry sand capping material with bottom-dump barge, side-casting, bucket/clamshell, tremie (gravity-fed downpipe)) and hydraulical (wet/slurry of sand placed from a pipe or tremie, or from a spreader barge) placement of the capping material (USACE 2005a and 2006, USEPA 1994, Palermo *et al.* 2011). Mechanical methods rely on the gravity settling of the granular capping materials in the water column (Palermo *et al.* 2011) which can result in less water column dispersion than discharge of hydraulically-handled cap material because it settles faster in the water column (USACE 1991).

Hydraulic methods can allow for a more precise placement of the material at the surface or depth but may require use of a dissipation device to reduce sediment resuspension (Palermo *et al.* 2011, USACE 1991).

Placing sand capping material in layers has been found to allow gentle spreading, resulting in a more stable sand cap (Ling and Leshchinsky undated), and avoiding displacement of or mixing with the underlying sediment (USEPA 2005). This results in a decrease in the turbidity plume with each successive cap layer. The reduction in sediment resuspension observed by placing granular capping material in lifts or layers may afford the ability to place subsequent layers using an alternative methodology that would allow faster placement (USEPA 2008). Therefore, once the sand layer of the proposed armoring is in place, the placement of the gravel would have limited potential to result in sediment resuspension. With the implementation of these methods of placement of granular capping material that have been proven to reduce sediment resuspension during placement, additional sediment resuspension that would occur during the placement of the armoring material would be minimized and would not be expected to result in adverse water quality impacts.

There will also be increases in suspended sediment during cofferdam construction and during pile driving. Available information indicates that turbidity levels during these activities will be about 30% and 40% of average resuspension levels experienced during dredging, respectively (FHWA 2012); therefore, increases in suspended sediment are expected to be less than 50 mg/l. 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.

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). The Normandeau 2001 report identified five species in the Kennebec River for which TSS toxicity information was available. The most sensitive species reported was the four spine stickleback which demonstrated less than 1% mortality after exposure to TSS levels of 100mg/L for 24 hours. Striped bass showed some adverse blood chemistry effects after 8 hours of exposure to TSS levels of 336mg/L. While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, shortnose and Atlantic sturgeon juveniles and adults are often documented in turbid water and Dadswell et al. (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.

The life stages of sturgeon most vulnerable to increased sediment are eggs and larvae which are subject to burial and suffocation. As noted above, no eggs and/or larvae will be present in the action area. Juvenile and adult sturgeon are frequently found in turbid water and would be capable of avoiding any sediment plume by swimming higher in the water column. Laboratory studies (Niklitschek 2001 and Secor and Niklitschek 2001) have demonstrated shortnose sturgeon are able to actively avoid areas with unfavorable water quality conditions and that they will seek out more favorable conditions when available. TSS is most likely to affect subadult or adult Atlantic sturgeon if a plume causes a barrier to normal behaviors or if sediment settles on the bottom affecting their benthic prey. Because any increase in suspended sediment is likely to be within the range of normal suspended sediment levels in the Hudson River, it is unlikely to affect the movement of individual sturgeon. Even if the movements of sturgeon were affected, these changes would be small. As sturgeon are highly mobile any effect on their movements or behavior is likely to be insignificant. Additionally, the TSS levels expected (<112mg/l) are below those shown to have an adverse effect on fish (580.0 mg/L for the most sensitive species, with 1,000.0 mg/L more typical; see summary of scientific literature in Burton 1993) and benthic communities (590.0 mg/L (EPA 1986)); therefore, effects to benthic resources that sturgeon may eat are extremely unlikely. Based on this information, it is likely that the effects of increased suspended sediment and turbidity will be insignificant.

### 7.7 Contaminant Exposure

Resuspension of sediments by dredging 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), and the limited areal extent of any sediment plume expected to be generated, any mobilization of contaminated sediments is expected to be minor (FHWA 2012). 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 bridge, 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.

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

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.

With the exception of Total PCBs, expected water concentrations of the contaminants that may be mobilized during the bridge replacement project are well below the NYSDEC and EPA water quality criteria. Levels of Total PCBs may be above the NYSDEC water quality criteria at 500 feet from the dredge, but the concentrations are still well below the EPA's criteria for PCB exposure. 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.

**Table 11**. FHWA's Comparison of Calculated Water Concentrations to NYSDEC TOGS 1.1.1 and EPA Water Quality Criteria.

| **Contaminant** | **Expected Water Concentration (mg/L) 500 feet down river of dredged based on 164 mg/L sediment Plume** | **Expected Water Concentration (ug/L)** | **NYSDEC Water Quality Criteria (ug/L) (Hudson River classified as Class SB (A(C))** | **EPA Water Quality Criteria (CMC and CCC) ug/L** | |
|---|---|---|---|---|---|
| Arsenic | 1.33E-04 | 0.133 | 63 | 69 | 36 |
| Cadmium | 1.79E-05 | 0.0189 | 7.7 | 40 | 8.8 |
| Copper | 3.18E-04 | 0.318 | 3.4 | 4.8 | 3.1 |
| Lead | 8.02E-05 | 0.0802 | 8 | 210 | 8.1 |
| Mercury | 3.56E-06 | 0.00356 | 0.05 | 1.8 | 0.94 |
| Total PCBs | 4.99E-07 | 0.000499 | 0.000001 | - | 0.014 |
| | | | | | |

### 7.8 Bridge Demolition

Bridge demolition would occur in two stages. The first stage includes partial demolition to allow for construction of the replacement bridge in the vicinity of the Westchester shoreline. The second stage includes the remaining demolition after completion of the replacement bridge. Use of turbidity curtains during removal of the columns and footings and cutting of the timber piles would minimize the potential for sediment resuspended during the bridge removal activities to affect water quality. Following removal of the existing bridge, sediment that has been deposited within mounds in the vicinity of the existing bridge piers may erode over time until reaching a new equilibrium elevation. Because the Tappan Zee portion of the Hudson River is considered to be neither a depositional or erosional environment (i.e., in equilibrium) (Nitsche *et al.* 2007), the erosion of these sediments in the vicinity of the existing bridge would be limited under normal river conditions and would most likely occur during high flow events. While some of these sediment deposits have elevated concentrations of certain contaminants (Class B or Class C categories), these elevated concentrations do not extend more than a few feet below the mudline. Therefore, the gradual erosion of some areas of contaminated sediment following the removal of the bridge would not be expected to result in adverse impacts to water quality or result in water quality conditions that fail to meet the Class SB standards.

Turbidity curtains would be used during removal of the columns and footings as well as cutting of the timber piles would minimize the potential for sediment that may be resuspended during bridge removal activities to affect benthic macroinvertebrates and other aquatic biota. Since the benthic sampling program for the project indicated similar benthic community structure in bottom sediments at both existing and proposed bridge location, and because the demolition is not expected to substantially alter sediment characteristics, the benthic community recolonizing the restored bottom habitat following bridge demolition is expected to be similar to surrounding areas. Demolition of the existing bridge would also remove the benthic invertebrates and algae that are attached to the bridge, which provide forage and structural habitat for fish. However, the new bridge would offset much of these losses by providing similar structural habitat for these species. Any effects to sturgeon due to increased water column suspended sediments from bridge demolition activities are expected to be minimal and temporary, and effects to feeding or behavior would be insignificant.

## 7.9 Operation of new bridge

Potential effects of the new bridge include habitat alteration/loss of benthic habitat, shading and storm water runoff. These effects are considered below. It is important to note that because the existing bridge will be removed, there is not likely to be a net change in the conditions in the river as compared to now. The new bridge is expected to have an operational life of approximately 100 years before substantial structural replacements would be required. The total anticipated lifespan before a new crossing is needed would be 150 years.

### *7.9.1 Shading*

Shading of estuarine habitats can result in decreased light levels and reduced benthic and water-column primary production, both of which may adversely affect invertebrates and fishes that use these areas, particularly with respect to use as refuge and foraging habitat (Able et al. 1998, and Struck et al. 2004). The amount of area shaded by overwater structures will be affected by the height and width of the structure, construction materials and orientation of the structure relative to the arc of the sun (Burdick and Short 1995, Fresh et al. 1995 and 2000, Olson et al. 1996, 1997 in Nightingale and Simenstad 2001) as well as piling density. Shading due to bridges has been found to affect plant communities such as tidal marshes and SAV, as well as benthic invertebrate communities within tidal marshes (Struck et al. 2004, and Broome et al., 2005 in CZR 2009). However, adverse effects on marsh vegetation and benthic macroinvertebrates have been found to be minimal when the bridge height-to-width ratio is greater than 0.7 (Struck et al, 2004, Broome et al. 2005 in CZR 2009). Significantly fewer oligochaete worms, which are common in the Hudson River, were found under bridges with a height-to-width ratio less than 0.7 when compared to marshes not affected by shading (Struck et al. 2004). Struck et al. (2004) found that bridges with height-to-width ratios greater than 1.5 had the lowest light attenuation beneath the bridge.

Because the elevations of the existing Tappan Zee Bridge and the new bridge are not consistent over the length of the structure, the height-to-width ratio of the bridge varies along its length. [redacted] While there are no vegetated wetlands or SAV that could be affected by the construction of the new bridge, the height-to-width ratios presented below provide an indication of the potential for the existing and new bridges to result in shading impacts. [redacted]

The separation between the decks of the two spans [redacted] allows light to penetrate between the two structures. The new bridge will have less shading than the existing bridge, including the permanent platform. Considering the extensive area of aquatic habitat not affected by shading within the area, any effects to sturgeon from the shading caused by the permanent platform and by the bridge are extremely unlikely.

### *8.9.2 Habitat Alteration*

Because the existing bridge will be removed and the new bridge piers will have a smaller footprint, the only net change in available benthic habitat will be from the permanent platform to be located along the Rockland County shoreline. The estimated acreage of habitat loss due to the pile footprints of the permanent platform is <0.1 acres. The area of permanent habitat loss is equivalent to <0.01% of the available soft-sediment benthic habitat in the Tappan Zee region [redacted] The permanent platform will be constructed in water depths of 6-10 feet and will extend out from the Rockland County shoreline along the upstream edge of the proposed bridge. [redacted] Sturgeon are only likely to be present in the shallow waters along the shoreline if suitable forage is present. The effects of the loss of forage are considered above and were determined to be insignificant. Given the small size of the platform and the extremely small loss of soft-bottom benthic habitat, effects to sturgeon are likely to be limited to the loss insignificant and discountable.

### *7.9.3 Stormwater Runoff*

Stormwater runoff will flow directly from the decks of the replacement bridge to the Hudson River. Because the existing bridge will be removed, there is little net change in stormwater runoff anticipated. NYSDEC General Permit GP-0-10-001 regulates the discharge of stormwater runoff from construction activities associated with soil disturbance, including both water quality and quantity controls. NYSDEC requires treatment of stormwater runoff from areas of soil disturbance to improve water quality, as well as a reduction of peak flows of stormwater runoff providing channel protection, overbank flood protection and flood control. The stormwater quality management goals are to achieve an 80 percent reduction in TSS and a 40 percent reduction in total phosphorous (TP).

The Hudson River is not on the State's Section 303(d) list of waterbodies impaired by stormwater runoff or within a watershed improvement strategy area. Stormwater runoff from the existing bridge is therefore not impairing water quality in the action area. As noted in the DEIS, with the implementation of post-construction or long-term quality treatment controls at the bridge landings, the net concentration of pollutants to the Hudson River from the new bridge is expected to decrease for TSS and increase by only 4.6 pounds per year for TP. FHWA has determined that this increase in TP loadings from the new bridge would not result in adverse impacts to water quality of the Hudson River, or result in a failure to meet the Class SB water quality standards. As such, effects to shortnose and Atlantic sturgeon from the discharge of stormwater to the Hudson River from the new bridge will be insignificant and discountable.

### *7.9.4 Climate Change Related Effects*

In the FEIS, FHWA considers effects of the construction and operation of the new bridge on greenhouse gas (GHG) emissions and energy use. According to FHWA, the new bridge would not increase traffic volumes or reduce vehicle speeds; therefore, fuel consumption and greenhouse gas emissions would be largely unaffected by the shift in traffic from the existing bridge to the new bridge.

As noted in the FEIS, while the contribution of any single project to climate change is infinitesimal, the combined GHG emissions from all human activity impact the global climate. Total GHG emissions associated with construction of the project are projected to be approximately 0.5 million metric tons. Annual global emissions of GHG are currently approximately 9 billion metric tons; the contribution from the bridge replacement project are approximately 0.006% of total global emissions. As there is an extremely small contribution to total global emissions, we expect any effect of these emissions on listed species to be insignificant and discountable.

In section 6.0 above we considered effects of global climate change, generally, on shortnose and Atlantic sturgeon. 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 during the time period when the Tappan Zee Bridge is being replaced (i.e., through 2016). It is possible that there will be effects to sturgeon over the time period that the new bridge is in place (expected to be a 150 year period); as explained above, based on currently available information and predicted habitat changes, these effects are most likely to be changes in distribution of sturgeon throughout the Hudson River and changes in seasonal migrations through the Tappan Zee reach of the river. The presence and continued use of the bridge over the next 100 years will not affect the ability of these species to adapt to climate change or affect their movement or distribution within the river.

## 7.10 Mitigation Plan Implementation as Required by the NYSDEC Permit

The authorization issued on March 27, 2013 by NYSDEC requires the implementation of an Endangered and Threatened Species Mitigation Plan and a Compensatory Mitigation Plan as well as compliance with a number of permit conditions. Here, we consider the effects of the implementation of those plans on Atlantic and shortnose sturgeon.

### *7.10.1 NYSDEC Endangered and Threatened Species Mitigation Plan*

The mitigation plan has four primary components: (1) mapping of Hudson River shallows to document benthic habitat used by Atlantic and shortnose sturgeon; (2) studying foraging habits using gastric lavage to obtain gut contents from Atlantic and shortnose sturgeon; (3) acoustically tagging and tracking Atlantic and shortnose sturgeon; and, (4) developing and implementing an outreach campaign directed at the commercial fishing industry.

*Mapping*

Mapping of Hudson River shallows less than five meters deep will extend from the Troy Dam south to New York Harbor. Techniques will be consistent with methods used by the NOAA Coastal Services Center, which relies primarily on the use of sidescan sonar or chirp sub-bottom profilers. No effects to Atlantic or shortnose sturgeon are anticipated to result from these survey efforts. This is because aerial and submerged videography will not interact with sturgeon. The equipment that is used operates at a relatively high frequency, above the hearing threshold of sturgeon (a typical chirp operates at 2-16 kHZ, with sturgeon only capable of hearing up to about 1 kHz). This means that sturgeon cannot perceive the sound emitted from the survey equipment.

*Gastric Lavage*

Gastric lavage, or stomach flushing, is used to remove food items from the stomachs of live fish by pumping water through a tube into a fish's stomach to induce regurgitation (Haley 1998; Damon-Randall et al. 2010). While invasive, when carried out properly, there is little risk of injury or mortality; it is considered to be the least injurious, nonlethal technique available for examination of sturgeon stomach contents (Damon-Randall et al. 2010). No injury or mortality of sturgeon captured or sampled in this way is anticipated. Because capture of Atlantic and shortnose sturgeon and subsequent gastric lavage is directed research, a take exemption must be obtained pursuant to Section 10 of the ESA. It is our understanding that NYSDEC is seeking to modify their existing Section 10 permits (#16439 and #16436, see discussion in section 6.1 above) to authorize this sampling. When the permit modification is proposed, a determination will be made as to whether the existing section 7 consultations regarding the issuance of these two research permits need to be reinitiated.

*Tagging and Tracking*

Sixty shortnose sturgeon and sixty Atlantic sturgeon will be captured and tagged with LOTEK Dual Mode sonic transmitters. Tracking of acoustically tagged fish will then be undertaken with both mobile and stationary receivers. The Section 10 permits held by NYSDEC authorize a certain amount of capture and sonic tagging. NYDEC has submitted a request to modify their existing permits to authorize the capture and tagging required by this permit. No injury or mortality of sturgeon captured or tagged is anticipated. During the permit modification process, a determination will be made as to whether the existing section 7 consultations regarding the issuance of these two research permits need to be reinitiated. No effects to sturgeon from carrying out the mobile or passive tracking efforts are anticipated.

*Outreach Efforts*

While there are no details of the outreach plan described in the permit, it is reasonable to expect that this effort will involve communication and development of literature. No effects to Atlantic or shortnose sturgeon are anticipated to result from the development of the outreach efforts.

### *7.10.2 NYSDEC Compensatory Mitigation Plan*

The compensatory mitigation plan contains four primary elements: (1) oyster restoration; (2) secondary channel restoration at Gay's Point; (3) wetlands enhancement at Piermont Marsh; and, (4) supplemental habitat replacement or enhancement.

*Oyster Restoration*

NYSTA is required to re-establish 13 acres of hard bottom/shell oyster habitat. This will be accomplished by harvesting oysters and reef materials from the area to be dredged and stockpiling these for future re-establishment. This re-establishment must occur as soon as possible after construction and shall take place in the vicinity of the new bridge; however, the specific location has not been defined. Local brood-stock may be provided to marine oyster hatcheries to be raised, spawned, and cultured, or an alternative may be proposed. No details on the oyster restoration, including the location of the restored habitat, identification of the sources for shell and non-shell material, and the location where broodstock will be cultured, are available at this time. Effects to shortnose and Atlantic sturgeon from oyster restoration are likely limited to minor habitat disturbances such as temporary increases in suspended sediment or turbidity if river sediments are disturbed. Oyster restoration is expected to have a beneficial effect on the Hudson River. We anticipate that any effects to Atlantic and shortnose sturgeon from the restoration activities will be insignificant and discountable.

*Channel Restoration at Gay's Point*
[redacted] The proposed channel restoration project will be designed to increase habitat diversity and function at Gay's Point. The viability of this project is related to cost-effectiveness, and it will only be carried out if the project goals can be achieved in a cost-effective manner. If it cannot, NYSTA will propose an alternative project. There is not sufficient information on the proposed activity to determine the likely effects to Atlantic or shortnose sturgeon from this activity. This activity will likely require a Rivers and Harbors Act Section 10 permit or Clean Water Act Section 404 permit issued by the USACE; therefore, we anticipate this action will undergo separate Section 7 consultation between us and the the lead Federal agency to assess the effects of any in-water activities on listed sturgeon.

*Wetlands Enhancement at Piermont Marsh*
NYSTA must design and implement a plan to enhance and restore Piermont Marsh, located in Nyack, NY. The plan must reduce invasive species (primarily Phragmites), restore the hydrologic connection of an oxbow in Crumkill Creek, enhance the quality of Sparkill Creek stormwater entering the marsh, and assess the feasibility of restoring historic wetlands. There are currently no conceptual or construction plans and the actual nature of the proposed activity is unknown. However, because sturgeon do not occur in the habitats where work will occur, they are unlikely to be exposed to any effects of the proposed wetlands enhancement.

*Supplemental Habitat Replacement or Enhancement*
NYSTA must submit to NYSDEC a plan for supplemental compensatory mitigation projects which have a total capital cost of $2 million. These plans must be implemented within seven years. As there are currently no conceptual or construction plans and the actual nature of the proposed activity is unknown, it is not possible to assess the impacts of these activities on shortnose and Atlantic sturgeon at this time. We anticipate that these actions will require authorization from the USACE and that unless USACE determines they will have no effect on listed species, they will undergo separate Section 7 consultation between us and the the lead Federal agency to assess the effects of any in-water activities on listed sturgeon.

## 8.0 CUMULATIVE EFFECTS
Cumulative effects, as defined in 50 CFR 402.02, are those effects of future State or private activities, not involving Federal activities, which are reasonably certain to occur within the action area. Future Federal actions are not considered in the definition of "cumulative effects."

Activities reasonably certain to occur in the action area and that are s carried out or regulated by the States of New York and New Jersey and that may affect shortnose and Atlantic sturgeon include the authorization of state fisheries and the regulation of point and non-point source pollution through the National Pollutant Discharge Elimination System. We are not aware of any local or private actions that are reasonably certain to occur in the action area that may affect listed species. It is important to note that the definition of "cumulative effects" in the section 7 regulations is not the same as the NEPA definition of cumulative effects. The activities discussed in the Cumulative Effects section of the FEIS - Champlain-Hudson Power Express and dredging at the US Gypsum and American Sugar facilities – will require authorization by the US Army Corps of Engineers, therefore they are considered future Federal actions and do not meet the definition of "cumulative effects" under the ESA and are not considered here.

While there may be other in-water construction or coastal development within the action area, all of these activities are likely to need a permit or authorization from the US Army Corps of Engineers and would therefore, be subject to section 7 consultation.

*State Water Fisheries* - Future recreational and commercial fishing activities in state waters may take shortnose and Atlantic 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 is 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.

*State PDES Permits* – The states of New York and New Jersey have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Some of the facilities that operate pursuant to these permits are included in the Environmental Baseline (e.g., Indian Point). Other permitees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the SPDES permits. 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.

## 9.0 INTEGRATION AND SYNTHESIS OF EFFECTS

Dredging to be carried out during the bridge replacement project is expected to result in the capture of no more than one shortnose sturgeon and one Atlantic sturgeon. These captured sturgeon are likely to be injured or killed. No capture, injury or mortality of sturgeon occurred during the dredging completed in 2013. The total amount of impact pile driving is expected to result in the injury of 37 or fewer shortnose sturgeon and 37 or fewer Atlantic sturgeon (34 New York Bight DPS, 2 Chesapeake Bay DPS, and one Gulf of Maine DPS). The pile driving completed through February 22, 2014, likely resulted in the minor injury of ten shortnose sturgeon and ten Atlantic sturgeon (9 NYB DPS and 1 Chesapeake Bay or Gulf of Maine DPS). Therefore, we anticipate the remaining impact pile driving to result in the minor injury of up to 27 additional shortnose sturgeon and 27 additional Atlantic sturgeon.

Normal sturgeon behavior is expected to result in avoidance of areas loud enough to cause significant injury or mortality. However, due to the length of the project and the duration of pile driving, we expect that no more than one shortnose sturgeon and no more than one Atlantic sturgeon will suffer serious injury or mortality due to exposure to pile driving noise. The two Atlantic sturgeon that are likely to be seriously injured or killed during dredging and pile driving are likely to be from the New York Bight DPS; however it is possible that they could also originate from the Gulf of Maine or Chesapeake Bay DPS. As explained in the "Effects of the Action" section of the Opinion, with the exception of the one shortnose sturgeon and one Atlantic sturgeon, 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.

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 above, effects of this temporary behavioral disturbance will be insignificant and discountable. As explained in the "Effects of the Action" section, effects of the bridge replacement project on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of piles by vibration, drilling to facilitate the installation of some piles, 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 any of the other effects including vessel traffic.

In the discussion below, we consider 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 three 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 and each of three DPSs of Atlantic 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 the listed species that may be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then 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 these species, as those terms are defined for purposes of the federal Endangered Species Act.

## 9.1 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 1,000 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 stable (Bowers-Altman *et al*. 2012 Draft).

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. Impingement also occurs at Indian Point; we have estimated an annual impingement rate of approximately eight sturgeon per 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. Over the life of the action, shortnose sturgeon in the Hudson River will continue to experience anthropogenic and natural sources of mortality. However, we are 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, we do not expect shortnose sturgeon to experience any new effects associated with climate change during the 3-4 year duration of the bridge construction. While climate change related effects to distribution in the river may occur during the period that the new Tappan Zee Bridge is in existence, the presence of the new bridge will not exacerbate or contribute to these effects or impact the ability of shortnose sturgeon to adapt to changing conditions in the river. As such, NMFS expects that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

We have estimated that the proposed bridge replacement project will result in injury to no more than 37 shortnose sturgeon, one of which is likely to die from its injuries and that one shortnose sturgeon will be captured and killed during dredging. We expect pile driving completed through February 22, 2014 resulted in the minor injury of ten shortnose sturgeon; therefore, we anticipate the minor injury of 27 additional shortnose sturgeon during the remaining installation of piles with an impact hammer. Other than for the fish that are killed, 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 re 1uPa RMS. 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 12 hours per day; over the duration of the Tappan Zee construction project, pile driving will be ongoing for approximately 7% of the time. Therefore, for the vast majority of time there will be no potential for behavioral disturbance. 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 5,000 feet of river width with noise levels less than 150 dB re 1uPa RMS which would allow unimpeded passage through this reach of the river; (2) any changes in movements would be limited to a period of no more than 12 hours per day when pile driving would be occurring (in total no more than 7% of the entire project duration); (3) any changes in movements would be limited to a very small area (radius of no more than 1,772 feet from the pile being driven, no more than 12% of the width of the river); (4) 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 pile driving will not preclude any shortnose sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected.

The number of shortnose sturgeon that are likely to die as a result of the proposed bridge replacement project (two), represents an extremely small percentage of the shortnose sturgeon population in the Hudson River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon rangewide, which is also stable. The best available population estimates indicate that there are approximately 56,708 (95%

CI=50,862 to 64,072) adult shortnose sturgeon in the Hudson River and an unknown number of juveniles (Bain 2007). While the death of up to 2 shortnose sturgeon over the five year construction period will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population or its stable trend as this loss represents a very small percentage of the population (less than 0.004%).

Reproductive potential of the Hudson population is not expected to be affected in any other way other than through a reduction in numbers of individuals. A reduction in the number of female shortnose sturgeon in the Hudson River would have the effect of reducing the amount of potential reproduction in this system as the fish killed would have no potential for future reproduction. However, it is estimated that on average, approximately 1/3 of adult females spawn in a particular year and approximately ½ of males spawn in a particular year. Given that the best available estimates indicate that there are more than 56,000 adult shortnose sturgeon in the Hudson River, it is reasonable to expect that there are at least 20,000 adults spawning in a particular year. It is unlikely that the loss of two shortnose sturgeon over a 5-year period would affect the success of spawning in any year. Additionally, this small reduction in potential spawners is expected to result in a small reduction in the number of eggs laid or larvae produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be very small and would not change the stable trend of this population. The loss of a male sturgeon may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. 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 and will not result in the death of spawning adults.

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. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is less than 0.004% of the Hudson River population, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species can have an appreciable effect on the numbers, reproduction and distribution of the species, this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of shortnose sturgeon because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity (see status of the species/environmental baseline section above), and there are thousands of shortnose sturgeon spawning each year.

Based on the information provided above, the death of up to two shortnose sturgeon between now and the end of 2017, resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of this species (i.e., the likelihood that the species will continue to exist in the future while retaining the potential for recovery) because, (1) it will not cause so many mortalities that the population will decrease; (2) the population trend of shortnose sturgeon in the Hudson River is stable at high levels; (3) the death of no more than two shortnose sturgeon over a five year period represents an extremely small percentage of the number of shortnose sturgeon in the Hudson River and an even smaller percentage of the species as a whole; (4) the loss of these shortnose sturgeon is not expected to impact the genetic heterogeneity of the Hudson River population of shortnose sturgeon or the species as a whole; (5) the loss of these shortnose sturgeon is likely to have such a small effect on reproductive output of the Hudson River population of shortnose sturgeon or the species as a whole that the loss of these shortnose sturgeon will have an extremely small impact on future year classes and will not change the status or trends of the Hudson River population or the species as a whole; and, (5) the action will have only a minor and temporary effect on the distribution of shortnose sturgeon in the action area (related to movements to avoid the ensonified area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of shortnose sturgeon to shelter and only an insignificant effect on individual foraging shortnose sturgeon.

In rare 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 shortnose sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where shortnose sturgeon are no longer in danger of extinction through all or a significant part of its range.

A Recovery Plan for shortnose sturgeon was published in 1998 pursuant to Section 4(f) of the ESA. The Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely. However, the plan states that the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks, (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Hudson River population of shortnose sturgeon in a way that would affect the species likelihood of recovery.

The Hudson River population of shortnose sturgeon has experienced an increasing trend and is currently stable at high levels. This action will not change the status or trend of the Hudson River population of shortnose sturgeon or the species as a whole. This is because the reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and discountable, and effects on distribution are temporary and small. The proposed action will not affect shortnose sturgeon outside of the Hudson River. Therefore, because it will not reduce the likelihood that the Hudson River population can recover, it will not reduce the likelihood that the species as a whole can recover. 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. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

## 9.2 Atlantic sturgeon

As explained above, the proposed action is likely to result in the injury of 37 or fewer Atlantic sturgeon due to exposure to underwater noise, one of which is likely to die, and the mortality of one Atlantic sturgeon due to capture in the dredge bucket. Based on the amount of pile driving completed to date, ten of these injuries have already occurred. We have considered the best available information to determine from which DPSs these individuals are likely to have originated. Any juveniles would originate from the Hudson River and the NYB DPS. Using mixed stock analysis explained above, we have determined that subadult and adult Atlantic sturgeon in the action area likely originate from three DPSs at the following frequencies: NYB 92%; Gulf of Maine 6%; and, Chesapeake Bay 2%. Given this, we expect that of the 37 injured fish, 34 will originate from the NYB DPS, two from the GOM DPS and 1 from the CB DPS. The fish likely to be captured in the dredge, is likely to be from the NYB DPS but it is possible that it could originate from either the CB or GOM DPS. The two Atlantic sturgeon likely to be killed are most likely to be NYB DPS; however, it is possible that one could originate from the GOM or CB DPS.

### 9.2.1 Gulf of Maine DPS

Subadult and adults originating from the GOM DPS occur in the action area. The GOM DPS is listed as threatened. While Atlantic sturgeon occur in several rivers in the GOM DPS, recent spawning has only been documented in the Kennebec; spawning is suspected to also occur in the Androscoggin river. No estimate of the number of Atlantic sturgeon in any river or for any life stage or the total population is available. The NEAMAP based estimates discussed in Section 4.2 estimate a total of 7,455 subadult and adult GOM DPS Atlantic sturgeon in the ocean.

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. We expect that 6% of the subadult and adult Atlantic sturgeon in the action area will originate from the GOM DPS. Most of these fish are expected to be subadults, with few adults from the GOM DPS expected to be present in the Hudson River.

We have estimated that the proposed bridge replacement project will result in the injury to 37 or fewer Atlantic sturgeon, of which two are likely to be from the GOM DPS. The following analysis applies to anticipated effects of capture and/or injury of up to 2 individuals, but given the nature of the effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 37 injured fish being from the GOM DPS. Sturgeon experiencing minor injuries are expected to fully recover. These injuries are unlikely to have any impact on fitness, likelihood of future survival or future reproduction. Therefore, the injury of these individuals will have no effect on the number, reproduction or distribution of the GOM DPS of Atlantic sturgeon.

We anticipate the mortality of two Atlantic sturgeon; these are both likely to originate from the NYB DPS; however, it is possible, that one of these sturgeon could originate from the GOM DPS; therefore, we consider the effects to the GOM DPS from the loss of one subadult (>760mm TL <1,500 mm TL). Here, we consider the effect of the loss of this individual on the reproduction, numbers and distribution of the GOM DPS.

The reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of one female subadult would have the effect of reducing the amount of potential reproduction as any dead GOM DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of one male subadult may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Reproductive potential of Atlantic sturgeon experiencing minor injuries due to noise exposure is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where GOM DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by GOM DPS fish.

Because we do not have a population estimate for the GOM DPS, it is difficult to evaluate the effect of the mortality caused by this action on the species. However, because the proposed actions will result in the loss of only one individual, we do not expect this to change the status or trend of the GOM DPS as this loss is thought to represent a very small percentage of the population.

The proposed action is not likely to reduce distribution because, while sturgeon may temporarily avoid areas where noise levels are higher than 150 dB re 1uPa RMS, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how GOM DPS sturgeon use the action area. Further, the actions are not expected to reduce the river by river distribution of Atlantic sturgeon.

Based on the information provided above, the death of up to 1 GOM DPS Atlantic sturgeon between now and the end of 2017, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one subadult GOM DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (2) the loss of one subadult will not result in the loss of any age class; (3) the loss of 1 subadult GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of 1 subadult GOM DPS Atlantic sturgeon between now and the end of 2017 is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of GOM DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging GOM DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the GOM DPS will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where the NYB DPS of Atlantic sturgeon is no longer in danger of extinction through all or a significant part of its range.

No Recovery Plan for the GOM DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the likelihood of recovery of the GOM DPS.

This action will not change the status or trend of the status and trend of the GOM DPS. The proposed action will result in a small amount of mortality (1 subadult over four years) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and effects on distribution are temporary and small. The proposed action will not affect Atlantic sturgeon outside of the Hudson River or affect habitats outside of the Hudson River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon or the natal rivers of GOM DPS origin Atlantic sturgeon. For these reasons, the action will not reduce the likelihood that the GOM DPS can recover. 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.

### 9.2.2 New York Bight DPS

The NYB DPS is 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. Given the proportion of Hudson River origin Atlantic sturgeon to Delaware River origin Atlantic sturgeon, we expect that the one or two NYB DPS origin Atlantic sturgeon killed during dredging or pile driving will originate from the Hudson River. There is limited information on the demographics of the Hudson River population of Atlantic sturgeon. An annual mean estimate of 863 mature adults (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). As discussed in Section 4.2, the NEAMAP based methodology estimates a total of 34,566 subadult and adult NYB DPS Atlantic sturgeon in the ocean.

No data on abundance of juveniles are available prior to the 1970s; however, catch depletion analysis estimated conservatively that 6,000-6,800 females contributed to the spawning stock during the late 1800s (Secor 2002, Kahnle *et al*. 2005). Two estimates of immature Atlantic sturgeon have been calculated for the Hudson River population, one for the 1976 year class and one for the 1994 year class. Dovel and Berggren (1983) marked immature fish from 1976-1978. Estimates for the 1976 year class at age were approximately 25,000 individuals. Dovel and Berggren estimated that in 1976 there were approximately 100,000 juvenile (non-migrant)

Atlantic sturgeon from approximately 6 year classes, excluding young of year.

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

Information on trends for Atlantic sturgeon in the Hudson River are available from a number of long term surveys. From July to November during 1982-1990 and 1993, the NYSDEC sampled the abundance of juvenile fish in Haverstraw Bay and the Tappan Zee Bay. The CPUE of immature Atlantic sturgeon was 0.269 in 1982 and declined to zero by 1990. This study has not been carried out since this time.

The Long River Survey (LRS) samples ichthyoplankton river-wide from the George Washington Bridge (rkm 19) to Troy (rkm 246) using a stratified random design (CONED 1997). These data, which are collected from May-July, provide an annual index of juvenile Atlantic sturgeon in the Hudson River estuary since 1974. The Fall Juvenile Survey (FJS), conducted from July – October by the utilities, calculates an annual index of the number of fish captured per haul. Between 1974 and 1984, the shoals in the entire river (rkm 19-246) were sampled by epibenthic sled; in 1985 the gear was changed to a three-meter beam trawl. While neither of these studies were designed to catch sturgeon, given their consistent implementation over time they provide indications of trends in abundance, particularly over long time series. When examining CPUE, these studies suggest a sharp decline in the number of young Atlantic sturgeon in the early 1990s. While the amount of interannual variability makes it difficult to detect short term trends, a five year running average of CPUE from the FJS indicates a slowly increasing trend since about 1996. Interestingly, that is when the in-river fishery for Atlantic sturgeon closed. While that fishery was not targeting juveniles, a reduction in the number of adult mortalities would be expected to result in increased recruitment and increases in the number of young Atlantic sturgeon in the river. There also could have been bycatch of juveniles that would have suffered some mortality.

In 2000, the NYSDEC created a sturgeon juvenile survey program to supplement the utilities' survey; however, funds were cut in 2000, and the USFWS was contracted in 2003 to continue the program. In 2003 – 2005, 579 juveniles were collected (N = 122, 208, and 289, respectively) (Sweka et al. 2006). Pectoral spine analysis showed they ranged from 1 – 8 years of age, with the majority being ages 2 – 6. There has not been enough data collected to use this information to detect a trend, but at least during the 2003-2005 period, the number of juveniles collected increased each year which could be indicative of an increasing trend for juveniles.

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. The largest single source of mortality appears to be capture as bycatch in commercial fisheries operating in the marine environment. A bycatch estimate provided by NEFSC indicates that approximately 376 Atlantic sturgeon die as a result of bycatch each year (NMFS NEFSC 2011). Mixed stock analysis from the NMFS NEFOP indicates that 49% of these individuals are likely to originate from the NYB and 91% of those likely originate from the Hudson River, for a total of approximately 167 adult and subadult mortalities annually. Because juveniles do not leave the river, they are not impacted by fisheries occurring in Federal waters. Bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (shad), has now been closed and there is no indication that it will reopen soon. NYB DPS Atlantic sturgeon are killed as a result of anthropogenic activities in the Hudson River and other rivers; sources of potential mortality include vessel strikes and entrainment in dredges. Based on available data, we estimate that an average of 19 NYB DPS Atlantic sturgeon are killed at the Indian Point intakes each year. There could also be the loss of a small number of juveniles at other water intakes in the River including the Danskammer and Roseton plants.

We have estimated that the proposed bridge replacement project will result in the minor injury of 37 or fewer Atlantic sturgeon due to exposure to pile driving noise; we expect 34 of these sturgeon (34 total) to be from the NYB DPS. The following analysis applies to anticipated effects of injury of up to 34 individuals, but given the nature of the effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, that all 37 injured fish are from the NYB DPS. Sturgeon experiencing minor injuries are expected to fully recover. These injuries are unlikely to have any impact on fitness, likelihood of future survival or future reproduction. Therefore, the injury of these individuals will have no effect on the number, reproduction or distribution of the NYB DPS of Atlantic sturgeon.

We expect that one of the sturgeon injured during pile driving will die and that one Atlantic sturgeon captured during dredging will be killed; these two fish are likely to originate from the NYB DPS. We expect that these mortalities will be juveniles (<500 mm TL) or subadults (<1,500 mm TL). The subadult NYB DPS Atlantic sturgeon could originate from the Hudson or Delaware River.

The overall ratio of Delaware River to Hudson River fish in the DPS as a whole is unknown. Some Delaware River fish have a unique genetic haplotype (the A5 haplotype); however, whether there is any evolutionary significance or fitness benefit provided by this genetic makeup is unknown. Genetic evidence indicates that while spawning continued to occur in the Delaware River and in some cases Delaware River origin fish can be distinguished genetically from Hudson River origin fish, there is free interchange between the two rivers. This relationship is recognized by the listing of the New York Bight DPS as a whole and not separate listings of a theoretical Hudson River DPS and Delaware River DPS. Thus, while we can consider the loss of Delaware River fish on the Delaware River population and the loss of Hudson River fish on the Hudson River population, it is more appropriate, because of the interchange of individuals between these two populations, to consider the effects of this mortality on the New York Bight DPS as a whole.

The mortality of two juvenile or subadult Atlantic sturgeon from the NYB DPS between now and the end of 2017 represents a very small percentage of the subadult and juvenile population . While the death of up to two juvenile or subadult Atlantic sturgeon will reduce the number of

NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the juvenile and subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined).

The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of two female juveniles or subadults would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of two male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that for any sturgeon that are not killed, any impacts to behavior will be minor and temporary and there will not be any delay or disruption of movements to the spawning grounds or actual spawning. .

The proposed action will also not affect the spawning grounds within either the Delaware or Hudson rivers where NYB DPS fish spawn. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds or result in the mortality of any spawning adults.

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 temporary avoidance of the area where noise is louder than 150 dB re 1uPa RMS. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon.

Based on the information provided above, the death of up to two NYB DPS Atlantic sturgeon between now and the end of 2017 resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these juvenile or subadult NYB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these

NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of one subadult will not result in the loss of any age class; (5) the loss of these NYB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (6) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (7) the action will have no effect on the ability of NYB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging NYB DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where the NYB DPS of Atlantic sturgeon is no longer in danger of extinction through all or a significant part of its range.

No Recovery Plan for the NYB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Hudson River population of Atlantic sturgeon in a way that would affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson River population of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will result in a small amount of mortality (no more than 2 individuals) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and discountable and the area of the river that sturgeon will be precluded from (due to high temperatures) is small. The proposed action will not affect Atlantic sturgeon outside of the Hudson River or affect habitats outside of the Hudson River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. Because it will not reduce the likelihood that the Hudson River population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. 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 endangered. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

### 9.2.3 Chesapeake Bay DPS

Subadults and adults originating from the CB DPS occur in the action area. The CB DPS is listed as endangered. Based on Mixed Stock Analysis, two percent of the subadult and adult Atlantic sturgeon in the action area likely originate from the CB DPS. While Atlantic sturgeon occur in several rivers in the CB DPS, recent spawning has only been documented in the James River. 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. The NEAMAP based methodology explained in Section 4.2 estimates a total of 8,811 subadult and adult CB DPS Atlantic sturgeon in the ocean.

We have estimated that the proposed bridge replacement project will result in the injury of 37 or fewer Atlantic sturgeon due to exposure to increased underwater noise during pile driving. With the exception of one individual which is likely to suffer significant injuries and die, these fish are expected to experience only minor injuries. The following analysis applies to anticipated effects of capture and injury of one individual, but given the nature of these effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 37 injured fish being from the CB DPS. Sturgeon experiencing minor injuries are expected to fully recover. These injuries are unlikely to have any impact on fitness, likelihood of future survival or future reproduction. Therefore, the injury of these individuals will have no effect on the number, reproduction or distribution of the CB DPS of Atlantic sturgeon.

We anticipate the mortality of two Atlantic sturgeon (one due to pile driving injuries, one captured and killed during dredging); these are both likely to originate from the NYB DPS; however, it is possible, that one of these sturgeon could originate from the CB DPS; therefore, we consider the effects to the CB DPS from the loss of one subadult (>500mm TL <1,500 mm TL). Here, we consider the effect of the loss of this individual on the reproduction, numbers and distribution of the CB DPS.

The reproductive potential of the CB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of one female subadult would have the effect of reducing the amount of potential reproduction as any dead CB DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. Reproductive potential of Atlantic sturgeon experiencing minor injuries due to noise exposure is not expected to be affected in any way. The loss of two male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where CB DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by CB DPS fish.

Because we do not have a population estimate for the CB DPS, it is difficult to evaluate the effect of the mortality caused by this action on the species. However, because the proposed actions will result in the loss of only one individual, we do not expect this to change the status or trend of the GOM DPS as this loss is thought to represent a very small percentage of the population.

The proposed action is not likely to reduce distribution because the actions will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the action area that may be used by CB DPS subadults or adults. Further, the actions are not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area where noise levels are higher than 150 dB re 1uPa RMS.

Based on the information provided above, the death of up to 1 CB DPS Atlantic sturgeon between now and the end of 2017, will not appreciably reduce the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one subadult CB DPS Atlantic sturgeon is an extremely small percentage of the population and will not change the status or trends of the species as a whole; (2) the loss of one subadult will not result in the loss of any age class; (3) the loss of 1 subadult CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of 1 subadult CB DPS Atlantic sturgeon between now and the end of 2017 is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of CB DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging CB DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the CB DPS will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where the CB DPS of Atlantic sturgeon is no longer in danger of extinction through all or a significant part of its range.

No Recovery Plan for the CB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the likelihood of recovery of the CB DPS.

This action will not change the status or trend of the status and trend of the CB DPS. The proposed action will result in a small amount of mortality (1 subadult over five years) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and effects on distribution are temporary and small. The proposed action will not affect Atlantic sturgeon outside of the Hudson River or affect habitats outside of the Hudson River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon or the natal rivers of CB DPS origin Atlantic sturgeon. For these reasons, the action will not reduce the likelihood that the CB DPS can recover. 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.

## 10.0 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 replacement of the Tappan Zee Bridge as described in section 3.0 of this Opinion, may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or the Gulf of Maine, New York Bight or Chesapeake Bay DPS of Atlantic sturgeon. No critical habitat is designated in the action area; therefore, none will be affected by the proposed action.

## 11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. 1538(g). A "person" is defined in part as any entity subject to the jurisdiction of the United States, including an individual, corporation, officer, employee, department or instrument of the Federal government (see 16 U.S.C. 1532(13)). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of carrying out an otherwise lawful activity 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. In issuing ITSs, NMFS takes no position on whether an action is an "otherwise lawful activity."

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 grants, 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 ITS exempts take for activities that have not yet occurred. This Biological Opinion is a result of the reinitiation of a consultation that concluded with the issuance of an Opinion on April 10, 2013. That Opinion included an ITS exempting the take of shortnose sturgeon and five DPSs of Atlantic sturgeon. Pile driving completed to date has likely resulted in the injury of ten shortnose sturgeon and ten Atlantic sturgeon, expected to be from the NYB DPS. This past take of those sturgeon was exempted by the ITS accompanying the April 2013 Opinion.

### 11.1 Amount or Extent of Take

Dredging to be carried out during the bridge replacement project is expected to result in the capture and mortality of: one shortnose sturgeon and one Atlantic sturgeon (originating from any either the New York Bight, Gulf of Maine or Chesapeake Bay DPS).

Remaining pile driving to be carried out for the bridge replacement project is expected to result in the injury of 27 or fewer shortnose sturgeon and 27 or fewer Atlantic sturgeon (25 New York Bight DPS, 1 Chesapeake Bay DPS and 1 Gulf of Maine DPS). All of these fish are expected to suffer minor injuries with the exception of one shortnose sturgeon and one Atlantic sturgeon experiencing serious injury or mortality. The Atlantic sturgeon expected to be seriously injured or killed during pile driving is likely to be from the New York Bight DPS; however, it is possible that they could also originate from the Gulf of Maine or Chesapeake Bay DPS. As explained in the "Effects of the Action" section of the Opinion, with the exception of the one shortnose sturgeon and one Atlantic sturgeon, 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 other take is likely to be in the form of minor injury. 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 bridge replacement project on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of piles by vibration, drilling to facilitate the installation of some piles, potential exposure to contaminants, a localized increase in vessel traffic, effects to prey items, and effects of mitigation activities required by the NYSDEC. We have determined that all behavioral effects will be insignificant and discountable; consequently, they do not rise to the level of take. We do not anticipate any take of shortnose sturgeon due to any of the other effects, including vessel traffic and dredge disposal.

This ITS exempts the following take of shortnose sturgeon and NYB, GOM and CB DPSs of Atlantic sturgeon:

| | **Shortnose Sturgeon** | **Atlantic Sturgeon** |
|---|---|---|
| Type of Take | | |
| Capture (during dredging) | 1 (juvenile or adult) | 1 from the NYB DPS (juvenile or subadult), GOM (subadult) or CB (subadult) DPS |
| Injury (due to exposure to pile driving noise) | 27 (juvenile or adult) | 27 total |
| | | 25 NYB DPS (juvenile, subadult or adult) |
| | | 1 GOM DPS (subadult or adult) |
| | | 1 CB DPS (subadult or adult) |
| Mortality (dredge or pile driving noise)* | 2 (juvenile or adult) | 2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS |

*the sturgeon killed are a subset of the sturgeon captured or injured.

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.

Observers will be present to monitor all dredging activity; therefore, we expect that all take associated with dredging will be observed. While we have been able to estimate the likely number of shortnose and Atlantic sturgeon to be taken as a result of the bridge replacement project, it may be impossible to observe all sturgeon affected by the pile installation. This is because both shortnose and Atlantic sturgeon are aquatic species that 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. FHWA will carry out a monitoring plan during pile installation including monitoring the project area for the presence of injured or dead fish. We expect that any sturgeon that are seriously injured or killed would be detected because we expect that these fish would be present at the river surface and therefore, be observable. The difficulty is monitoring fish that remain underwater and experience minor injuries.

We considered several methods to monitor the validity of our estimates that there will be 27 or fewer, shortnose and 27 or fewer Atlantic sturgeon total from the New York Bight, Gulf of Maine and Chesapeake Bay DPSs 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 bridge replacement project. In addition, gillnets may be very effective at catching sturgeon; however, we chose a method of monitoring take that would not exacerbate adverse effects. Also, because we expect a wide variety of size classes of sturgeon to be present in the area near the bridge and different mesh sizes would be needed to catch different size fish, it would be difficult to establish a sampling design that would effectively capture fish of all size classes at all times. 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 surrogate 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 provides a surrogate for estimating the actual amount of incidental take. We expect that this surrogate 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. Because all of the calculations that were used to generate the take estimates are based on conservative scenarios, including rounding up any estimates that generated fractions of a fish to whole fish, we do not believe that we have underestimated take. We will consider incidental take exceeded if any of the following conditions are met:

i) More than 27 shortnose sturgeon are observed stunned or injured during pile driving.
ii) More than one dead shortnose sturgeon or more than one dead Atlantic sturgeon (belonging to the NYB, CB or GOM DPS) are observed during pile driving with injuries that are attributable to project operations.
iii) More than 25 New York Bight DPS, 1 Chesapeake Bay DPS, and 1Gulf of Maine DPS Atlantic sturgeon are observed stunned or injured during pile driving.
iv) More than one shortnose sturgeon and more than one Atlantic sturgeon (NYB, CB or GOM DPS) are observed captured (dead or alive) during mechanical dredging.

Additionally, we will consider whether incidental take was exceeded if either of the following conditions are met for pile installation with an impact hammer:

(a) The geographic extent of the area where noise is greater than 206 dB re 1 μPa peak is greater than the area considered in the "Effects of the Action" section of this Opinion (see Table 10), which is related to the area used to calculate the number of takes anticipated.

(b) We will consider whether incidental take was exceeded if the number of hours that impact pile driving occurs exceeds the amount of time listed in Table 10, which is related to the amount of time used to calculate the number of takes anticipated.

Some of the methods above (iii, iv) 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 expected that genetic test results could be obtained in time to reinitiate consultation prior to completion of the bridge replacement project as we anticipate receiving genetic information within approximately one month of submitting samples for processing.

### 11.2 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 and Atlantic 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 or dredging activities.

We believe 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. Please note that these reasonable and prudent measures and terms and conditions are in addition to the Environmental Performance Commitments that FHWA has committed to employ during the project (see Section 3.3). Because the Environmental Performance Commitments are mandatory requirements of the design build contract, we have not repeated them here as they are considered to be part of the proposed action. For example, FHWA has committed to only driving piles for 12 hours a day, only dredging the access channel between August 1 – November 1, using vibratory methods to the maximum extent practicable and implementing noise attenuation systems that achieve at least a 10 dB reduction during impact pile driving; as such, these measures are not repeated in the RPMs and Terms and Conditions below. We have reviewed these RPMs in light of the conditions of the permit issued by NYSDEC to ensure that there are no conflicting measures. We expect that should there be any questions about these measures, NYSDEC, NMFS, FHWA and the project sponsors will work together to resolve any uncertainty or perceived conflict.

***RPMs Specific to Dredging Activities:***

1. FHWA must provide NMFS with notice prior to the start and at the completion of each dredge cycle. Any request to extend access channel dredging beyond the August 1 – November 1 window must be coordinated with NMFS with the understanding that this is likely to require reinitiation of this consultation.

2. FHWA must ensure a NMFS-approved endangered species observer is present to observe all mechanical dredging activities to monitor for any capture of shortnose and Atlantic sturgeon.

3. The FHWA must ensure that all measures are taken to protect any sturgeon that survive capture in the mechanical dredge.

***RPMs Specific to Pile Driving Activities:***

4. FHWA must continue to implement a program to monitor underwater noise resulting from the installation of permanent piles four feet or more in diameter during pile installation operations.

5. FHWA must continue to implement a program to monitor a representative number of piles from underwater noise resulting from the installation of [redacted] piles.

6. FHWA must continue to implement a program to monitor impacts to sturgeon resulting from pile installation for permanent piles four feet or more in diameter throughout the duration of pile driving operations.

***RPMs for all aspects of the project:***

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

8. All Atlantic sturgeon captured must have a fin clip taken for genetic analysis. This sample must be provided to NMFS.

9. All shortnose and Atlantic sturgeon that are captured during the project must be scanned for the presence of Passive Integrated Transponder (PIT) tags. Tag numbers must be recorded and reported to NMFS. If no tag is present, a PIT tag of the appropriate size must be inserted.

10. A necropsy must be undertaken to attempt to determine the cause of death of any dead sturgeon observed during bridge construction that is judged to be suitable for necropsy, in consultation with NYSDEC and NMFS. After completion of the necropsy all dead shortnose and Atlantic sturgeon shall be delivered to the NYSDEC.

11. All sturgeon captures, injuries or mortalities associated with the bridge replacement project must be reported to NMFS within 24 hours.

## 11.3 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 incidental 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)). In carrying out all of these terms and conditions, FHWA as lead Federal agency in this consultation, is responsible for coordinating with the other Federal agencies that are party to the consultation, as well as with project sponsors and contractors.

1. To implement RPM #1, each year that dredging is undertaken, the FHWA in coordination with the ACOE, project sponsors and contractors as appropriate, must inform NMFS of the commencement of dredging operations at least one week prior to the actual start date and inform us of the number of dredges to be used, the area within the river to be dredged, the volume of material to be removed, the expected duration of dredging, and the disposal site to be used.

2. To implement RPM #1, at the end of each dredging operation, FHWA in coordination with the ACOE, project sponsors and contractors as appropriate, must provide us a report that summarizes dredge operations including information on the dates of dredging, the volume of material removed, the number of trips to the disposal site. This report must also contain copies of the dredge observer reports. This report must be submitted to us by December 31 of any year that dredging occurs.

3. To implement RPM #2, for mechanical dredging, the FHWA in coordination with the ACOE, project sponsors and contractors as appropriate, must ensure that observer coverage is sufficient for 100% monitoring of dredging operations. This monitoring coverage must involve the placement of a NMFS-approved observer on board the dredge for every day that dredging is occurring. The NMFS approved observer must observe all discharges of dredged material from the dredge bucket to the scow or hopper. All biological material must be documented by a NMFS-approved observer as outlined in Appendix A and be reported to NMFS by December 31 of any year that dredging occurs.

4. To implement RPM #2, at least two weeks prior to each dredge period, FHWA must submit to us the names and qualifications of any observers to be used on board the dredge(s). No observers can be deployed to the dredge site until FHWA has written confirmation from NMFS that they have met the qualifications to be a "NMFS-approved observer" as outlined in Appendix B. If substitute observers are required during dredging operations, FHWA must ensure that NMFS approval is obtain before those observers are deployed on dredges. Approval of any substitute observers may be by phone, to be followed by written confirmation.

5. To implement RPM #3, FHWA, in coordination with the ACOE and in accordance with the Dredging and Pile Driving Monitoring Plan, project sponsors and contractors as appropriate, any sturgeon observed in the dredge bucket or dredge scow during mechanical dredging operations must be removed and, if alive, returned to the river away from the project site after scanning and/or inserting PIT tags (see T&C #15 below) and documenting the interaction (see T&C #17 below).

6. To implement RPM #4, FHWA must ensure an acoustic monitoring program continues to be implemented that is able to document the underwater noise associated with a representative number [redacted] piles. 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 206 dB re 1 μPa Peak, 187 dB re 1 $\mu Pa^2$-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 during each 24 hour period.

7. To implement RPM #4, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with drilling rock to install any rock sockets. The monitoring program must be sufficient to establish the peak sound level and the cSEL during drilling.

8. To implement RPM #4, FHWA must ensure an acoustic monitoring program continues to be implemented that is able to document the underwater noise associated with installing [redacted] piles with a vibratory method. The monitoring program must be sufficient to establish the peak sound level and the RMS level.

9. To implement RPM #4, FHWA must report results from the sound monitoring to NMFS as soon as practicable, but no less frequently than every 30 days. If there is any indication that peak noise levels have exceeded 206 dB re 1 μPa peak for longer than anticipated or over a greater geographic area than anticipated, NMFS must be contacted immediately. Monthly reports must be provided to NMFS in a format that allows comparison to the information presented in Table 10 in the Opinion; therefore they must include the noise information and the duration of pile driving activities.

10. To implement RPM #5, FHWA must monitor underwater noise for a representative number of three-foot permanent piles to validate the noise levels used to estimate potential sturgeon take and to ensure that the authorized incidental take will not be exceeded during the driving of three-foot piles.

11. To implement RPM #6, FHWA must ensure acoustic telemetry equipment continues to be utilized to monitor for the presence, residence time and movement of tagged Atlantic and shortnose sturgeon in the project area during the installation of permanent pile [redacted]. FHWA must continue to implement a monitoring plan that would ensure the detection of acoustically tagged shortnose or Atlantic sturgeon in the action area. FHWA must ensure that all occurrences of tagged sturgeon in the project area are recorded and reported to NMFS to the extent that detected tags can be identified as shortnose or Atlantic sturgeon. Information collected from any stationary receivers must be downloaded at least every 60 days, unless there are weather or safety concerns in which case downloads must be made as soon as practicable after the relief of the weather or safety concern. Preliminary reports containing information on the number of tagged sturgeon detected must be provided to NMFS on a regular basis, but no less frequently than every 60 days. If reports cannot be provided on that frequency, FHWA must provide an explanation to NMFS within the 60 day period and provide the report as soon as possible. On a quarterly basis, FHWA must provide NMFS a report that summarizes the presence, residence time and movement of tagged Atlantic and shortnose sturgeon for the 90 day period. The quarterly report must be provided within 30 days of the end of the 90 day period. The report must also include the number of tags that could not be identified to species and document the steps that FHWA took to attempt to identify the species identification (e.g., contact the tag manufacturer). This term and condition does not require FHWA to tag any sturgeon with telemetry tags.

12. To implement RPM #6, FHWA must ensure the project area is monitored for the presence of any floating dead or injured sturgeon down-current of pile driving. FHWA must continue to implement the Dredging and Pile Driving Monitoring Plan that ensures the detection of any floating stunned, injured or dead sturgeon. Preliminary reports

containing information on the number of fish observed stunned or injured (including non-sturgeon species) must be reported to NMFS on a regular basis, but no less frequently than every 60 days. If reports cannot be provided on that frequency, FHWA must provide an explanation to NMFS within the 60 day period and provide the report as soon as possible.

13. To implement RPMs #4, 5 and 6, if FHWA determines that changes to the telemetry monitoring plan, acoustic monitoring plan (i.e., monitoring of noise produced during pile driving) or dredge monitoring plan are necessary, FHWA must submit a revised plan to NMFS and request concurrence with the proposed modifications. Within 14 days, NMFS will either submit written approval of the plan to FHWA or request additional information or modifications. Except in extenuating circumstances (e.g., extreme weather or situations threatening human life or safety), changes to the plan will not be implemented prior to receiving NMFS written approval of the revised plan. If extenuating circumstances are present, FHWA must notify NMFS at the time the revised plan is submitted for review.

14. To implement RPM #7, FHWA must ensure any observed live sturgeon are collected and are visually inspected for injuries. Unless the size of fish precludes holding, collected fish must be held with a flow through live well.

15. To implement RPM #8, FHWA must ensure that fin clips are taken (according to the procedure outlined in Appendix C) of any sturgeon captured during the project 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.

16. To implement RPM #9, FHWA must ensure all collected sturgeon must be inspected for a PIT tag with an appropriate PIT tag reader and tagged if no PIT tag is detected according to the protocol provided as Appendix D. Injured fish must be visually assessed, measured, photographed, released away from the site and reported to NMFS.

17. To implement RPM #10, FHWA must ensure that any observed dead sturgeon are collected, reported to NMFS, and if in suitable condition, preserved as appropriate to allow for necropsy, and that NMFS is contacted within 24 hours to discuss necropsy and disposal procedures. The form included as Appendix E must be completed and submitted to NMFS.

18. To implement RPM #11, if any live or dead sturgeon are observed or captured during any aspect of the proposed bridge replacement project, FHWA must ensure that NMFS (978-281-9328) is notified within 24 hours and that an incident report (Appendix E) 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 F 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 impacts of the project on listed species 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 bridge replacement project. 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 Term and Condition #1 and #2 are necessary and appropriate because they will serve to ensure that NMFS is aware of the dates and locations of all dredging. This will allow NMFS to monitor the duration and seasonality of dredging activities as well as give NMFS an opportunity to provide FHWA with any updated contact information for NMFS staff. This is only a minor change because it is not expected to result in any delay to the project and will merely involve an occasional telephone call or e-mail between FHWA and NMFS staff.

RPM #2 and the implementing Term and Conditions (#3 and 4) are necessary and appropriate because they require that the FHWA have sufficient observer coverage to ensure the detection of any interactions with listed species during dredging. This is necessary for the monitoring of the level of take associated with the proposed action. The inclusion of these RPMs and Terms and Conditions is only a minor change as the FHWA included observer coverage in the original project description and this just serves to clarify the responsibilities of the observer and ensure that all observers are qualified for their duties. This will not result in any delays. These also represent only a minor change as in many instances they serve to clarify the duties of the observers.

RPM #3 and Term and Condition #5 are necessary and appropriate to ensure that sturgeon that survive capture in a mechanical dredge are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality through inappropriate handling. This represents only a minor change as following these procedures will not result in an increase in cost or any delays to the proposed project.

RPM #4 and #5 Term and Condition #6-10 are necessary and appropriate because they are specifically designed to monitor underwater noise associated with pile installation. 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 pile driving and to allow NMFS and FHWA to determine if the level of incidental take is ever exceeded.

RPM #6 is necessary and appropriate because they will monitor direct impacts to sturgeon during pile installation. Term and Condition #11 is necessary and appropriate because 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. As explained on page 143 of this Opinion, we can not use the detection of tagged fish to indicate the amount of take that has occurred. As stated above, this is because we do not know what percentage of sturgeon in the action area are likely to be tagged; therefore, 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. This requirement represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays. Because we expect that not all tags detected by the receivers will be able to be identified to species, it is only reasonable to require FHWA to record and report tags that can be identified as shortnose and Atlantic sturgeon.

RPM#7 and Term and Condition #12 are necessary and appropriate to maximize the potential for detection of any floating stunned, injured or dead sturgeon downcurrent of pile driving operations. This allows us to monitor the amount of take resulting from the proposed action. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

Term and Condition #13 implements components of RPMs #4, 5 and 6. The purpose of this Term and Condition is to ensure that going forward, both NMFS and FHWA have a written record of any proposed changes to the monitoring plans as well as a written record of any approvals of those plans. This RPM will ensure that requests for changes and approval of those changes happens in writing which will allow us to monitor the implementation of the monitoring plans. This is necessary and appropriate because the monitoring plans are an important tool for monitoring take. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM#7-9 and Term and Condition #14-16 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. Checking and tagging fish with PIT tags allows FHWA to determine the identity of detected fish and determine if the same fish is detected more than once. PIT tagging is not known to have any adverse impact to fish. NMFS has received no reports of injury or mortality to any sturgeon sampled or tagged in this way. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM #10 and Term and Condition #17 are necessary and appropriate to determine the cause of death of any dead sturgeon observed during the bridge replacement project. This is necessary for the monitoring of the level of take associated with the proposed action. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM #11 and Term and Condition #18 are necessary and appropriate to ensure the proper documentation and reporting of any interactions with listed species. This is only a minor change because it is not expected to result in any delay to the project and will merely involve an occasional telephone call or e-mail between FHWA and NMFS staff.

## 12.0 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 any dead sturgeon removed from the Hudson River during the course of the bridge construction project to determine contaminant loads.
2. The FHWA should use its authorities to support studies on shortnose and Atlantic sturgeon distribution of individuals in the Tappan Zee reach of 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).
3. The FHWA should use its authorities to support studies on the distribution of shortnose and Atlantic sturgeon throughout different habitat types within the Hudson River. Such studies could include tagging and tracking studies and use of gross and fine scale acoustic telemetry equipment to monitor movements of individual fish throughout the river. This information would add to our knowledge of habitat selection and seasonal distribution throughout the river.
4. The FHWA should use its authorities to support studies necessary to update population estimates for the Hudson River population of shortnose sturgeon and the Hudson River population of Atlantic sturgeon.
5. The FHWA should use its authorities to conduct post-construction monitoring of the benthic environment to document recovery rates of benthic invertebrates in areas where temporary platforms were constructed, the existing bridge was removed and where dredging and/or armoring occurred.

## 13.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the Tappan Zee Bridge replacement project. 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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