ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Agency: Federal Highway Administration, New York Division (lead)
Army Corps of Engineers, New York District
U.S. Coast Guard

Activity: **Tappan Zee Bridge Replacement**
NER-2015-12923

Conducted by: NOAA's National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office

Date Issued: 20 JUNE 2016

Approved by: 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 Tappan Zee Bridge Replacement Project. The U.S. Federal Highway Administration (FHWA) is the lead agency for the bridge replacement. The U.S. Army Corps of Engineers (USACE) has issued a permit authorizing components of the bridge replacement under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. USACE also issued a permit to Tappan Zee Constructors (TZC) to authorize work in Coeymans, New York to establish a staging area for receiving steel and assembling components of the replacement bridge. The U.S. Coast Guard (USCG) has authorized the bridge replacement under the General Bridge Act of 1946.

We issued a Biological Opinion on the effects of the Tappan Zee Bridge Replacement Project to the FHWA, USACE, USCG and U.S. Environmental Protection Agency on June 22, 2012. This Opinion concludes the fifth reinitiation of that original consultation. To date, including an Opinion on a Pile Installation Demonstration Project issued March 7, 2012, we have issued six opinions on effects of the bridge replacement project, dated June 22, 2012, April 10, 2013, March 12, 2014, April 2, 2014, and September 23, 2014. This seventh opinion replaces the Opinion issued by us on September 23, 2014. 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 October 2015, a biological evaluation from the FHWA dated January 6, 2016, additional information provided in February 2016, and monitoring reports provided to us since construction of the bridge began in 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 Greater Atlantic 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 a 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 reviewed and provided comments on a Preliminary DEIS and the January 2012 DEIS. A meeting was held on December 14, 2011, to continue the coordination of the PIDP and the Project's BA 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. 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 22, 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 4-foot, 6-foot, 8-foot and 10-foot diameter 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 eight and ten foot diameter piles. Additionally, the dredged material disposal site changed and a supplemental Pile Installation Demonstration Project (PIDP or pile load testing) was proposed.

Consultation was reinitiated on February 25, 2013 and a final Opinion was issued on April 10, 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 was necessary to consider modifications of the proposed action which will have effects to listed species not considered in the 2013 Opinion. Specific changes included: 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, 2014 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 and a new Opinion was issued on April 2, 2014.

On May 9, 2014, USACE issued a Public Notice describing an application by TZC for authorization to carry out in-water work, including dredging and trestle construction at the Port of Coeymans. The stated purpose of the activity was "to allow assembly of approach span frames, provide sufficient access and draft within the existing active port and facilitate the barge slip transport and delivery operations in support of the New NY Bridge project[1]." As the activities proposed by the USACE met the definition of "inter-related" actions as that term is defined in the regulations implementing ESA section 7 (see 50 CFR 402.02, definition of "Effects of the Action"), reinitiation of consultation was requested on July 16, 2014, and a new Opinion was issued on September 23, 2014.

On June 4, 2015, a dead Atlantic sturgeon was collected by the project team. The necropsy report states "The severe injury distal to the dorsal fin clearly caused the death of this specimen from exsanguination. What caused this trauma is unknown. One possibility, given the appearance of sharp force trauma, would be a watercraft propeller. (June 5, 2015 Cornell Report). In their review of the necropsy report, NYSTA stated "These results suggest that vessel interaction was likely the cause of death for this sturgeon. While vessel activity is the likely cause of mortality for this fish, it is not possible to determine if the vessel that struck this sturgeon was a project vessel or one of the many other non-project vessels that traverse this part of the Hudson River." On July 22, 2015, we sent a letter to FHWA requesting additional information on project vessel operations. In a September 1, 2015 letter, FHWA provided a drift analysis prepared by NYSTA demonstrating that the injury to the sturgeon occurred greater than 2 miles upstream of the project location where the project's small vessels do not travel.

On August 13, 2015, a live injured shortnose sturgeon was collected from the river near the bridge replacement; the fish died later that day and vessel interaction was a suspected cause of death. The necropsy report concludes "…it is likely this sturgeon may have been struck by something blunt, such as the bow of a boat. No lacerations were noted that would lead us to think that a propeller strike had occurred and no severe external damage was observed that would suggest some type of crushing injury." (September 15, 2015 Cornell Report).

Discussions during August and September 2015 provided additional information on project vessels. The 2014 Opinion considered the operation of slow moving (less than six knots) barges and tug boats but did not consider faster-moving vessels associated with the project. Seventeen project vessels (i.e. crew vessels and delivery boats) move significantly faster than six knots, typically operating between 15 and 25 knots. Given that the operation of these vessels was not considered in our September 2014 Opinion, on September 11, 2015 FHWA requested that we reinitiate formal consultation. New information on the operating speeds of crew vessels, as well as new information on impacts of vessel operations on sturgeon in the Hudson River generally, constitutes new information that reveals effects of the action that may affect listed shortnose and Atlantic sturgeon in a manner or to an extent not previously considered. Therefore, reinitiation of section 7 consultation is appropriate. FHWA submitted an initial Biological Evaluation (BE) on

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[1] The "New NY Bridge Project" is the replacement of the Tappan Zee Bridge.

November 23, 2015, a revised BE on December 8, 2015 and a final BE on January 6, 2016. Additional information was also provided to us on February 2, 2016, February 19, 2016, April 21, 2016, May 13, 2016, May 31, 2016 and June 6, 2016.

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. USACE issued a permit to TZC for work at the Coeymans staging area. NYSTA and its contractors, including TZC, have designed and are constructing 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 is currently being 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. The location of the proposed bridge is illustrated in Figure 1; details of the project design are illustrated in Figures 2a-c.

The landings will tie in the new geometry of the proposed bridge with the geometry of the existing roadway. The landings will employ typical highway construction techniques and will be completed on both the Westchester and Rockland sides of the Hudson River upland from the bridge abutments. Construction of the landings will occur throughout the duration of the project. The construction activity for the landings is being staged, as the roadways on both sides are being altered and maintained before being altered again. The alterations to the landings 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 will 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 are being built sequentially so that as a new bent of piles is being driven, a new pile cap is being installed on a completed bent of piles. In-water work associated with building the approach spans involves pile and cofferdam installation.

The main span will stretch between the Westchester and Rockland approach spans across the federal navigation channel. This segment of the bridge is defined largely by its superstructure design as a cable stayed bridge. Within its substructure, the piers will be more substantial than those of the approaches. All main span work is being conducted sequentially and in a similar manner to the approaches. The construction of the piles, pile caps, pylons, and deck began in 2014 and will take approximately three and a half years to complete.

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

Construction requires 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 are 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 are transported from upland staging areas in Westchester and Rockland counties to work trestles that have been 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 are required to provide access to work areas in shallow portions of the proposed construction zone within the river.

Figure 1. Project Location

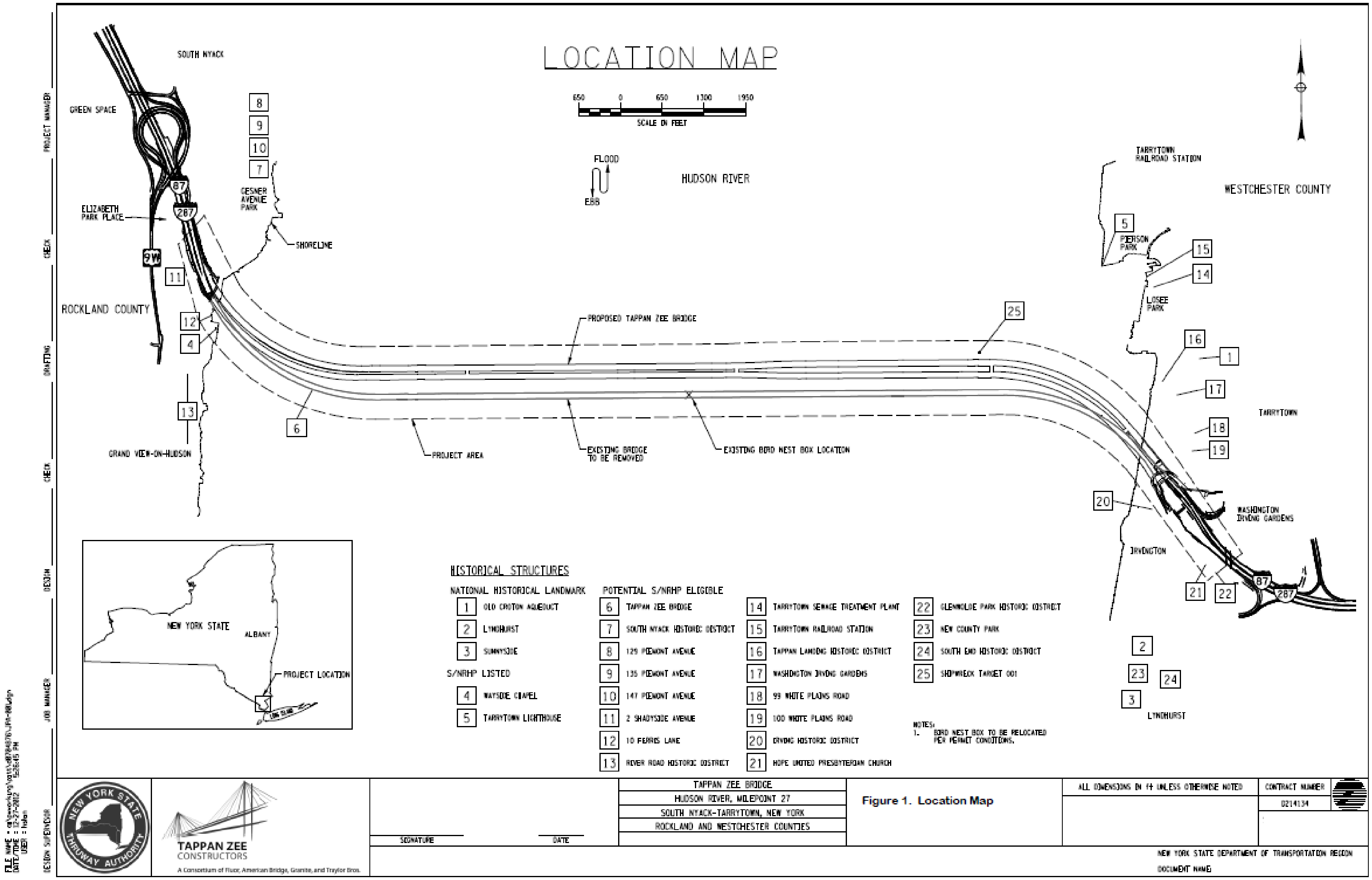


Figure 2a. Overall Landings Plan

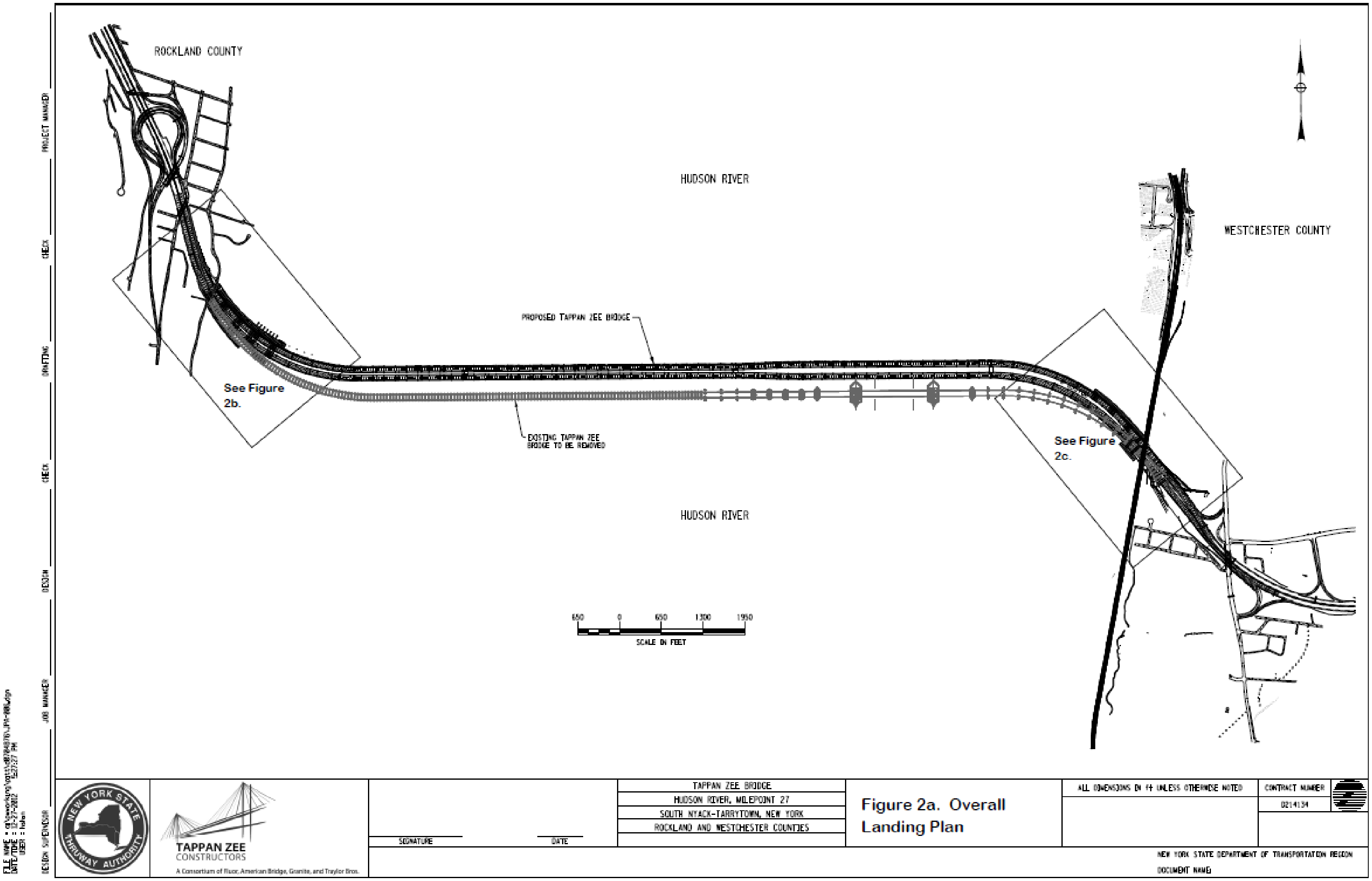
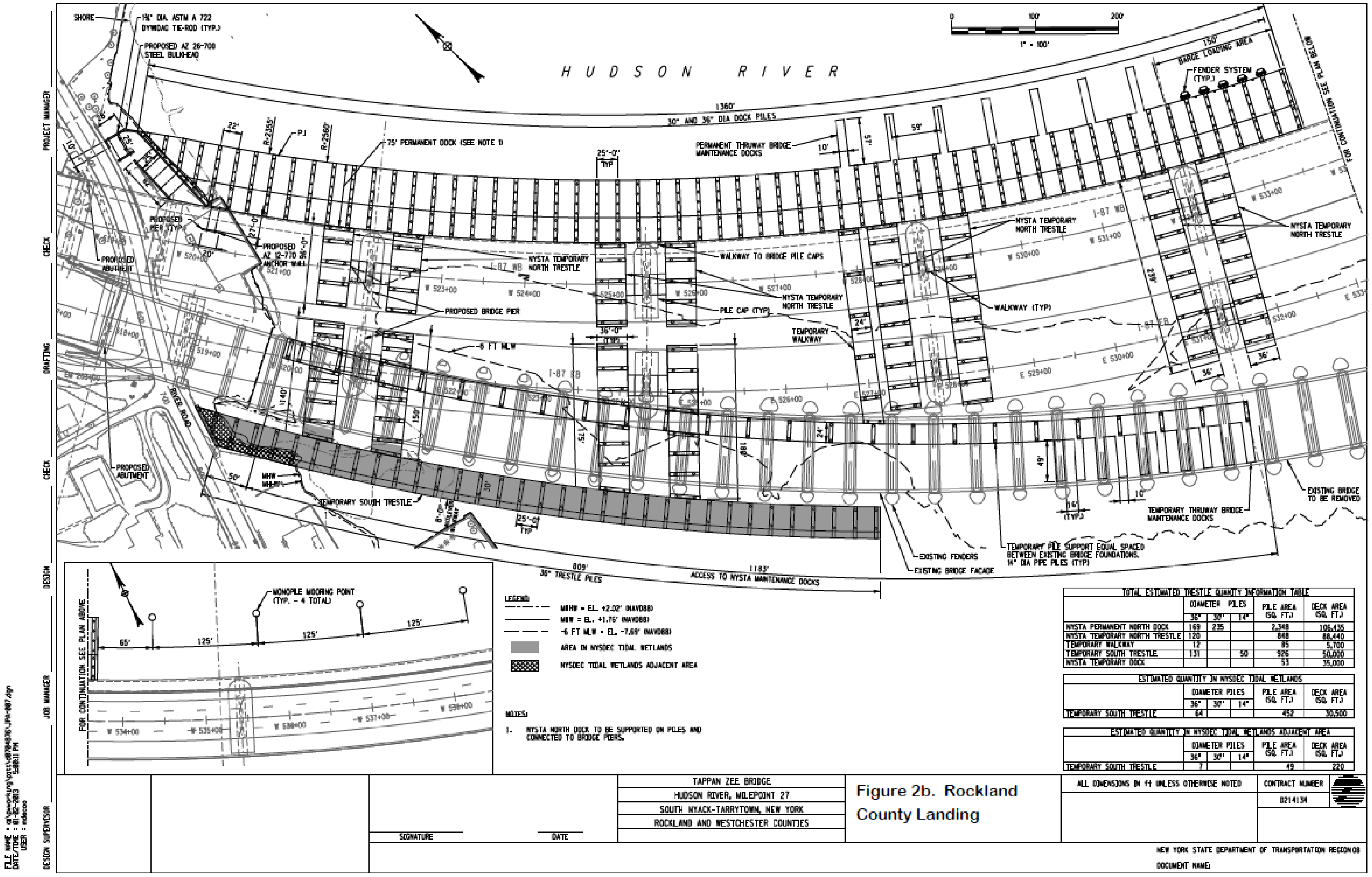


Figure 2b. Rockland County Landing



LEGEND:

- — - — - MHW = EL. +2.02' (NAVD88)
- ——— MLW = EL. +1.76' (NAVD88)
- — — — -6 FT MLW = EL. -7.69' (NAVD88)
- ▨ AREA IN NYSDEC TIDAL WETLANDS
- ▩ NYSDEC TIDAL WETLANDS ADJACENT AREA

NOTES:

1. NYSTA NORTH DOCK TO BE SUPPORTED ON PILES AND CONNECTED TO BRIDGE PIERS.

TOTAL ESTIMATED TRESTLE QUANTITY INFORMATION TABLE

	DIAMETER PILES			PILE AREA (SQ. FT.)	DECK AREA (SQ. FT.)
	36"	30"	14"		
NYSTA PERMANENT NORTH DOCK	169	235		2,348	106,435
NYSTA TEMPORARY NORTH TRESTLE	120			848	88,440
TEMPORARY WALKWAY	12			85	5,700
TEMPORARY SOUTH TRESTLE	131		50	926	50,000
NYSTA TEMPORARY DOCK				53	35,000

ESTIMATED QUANTITY IN NYSDEC TIDAL WETLANDS

	DIAMETER PILES			PILE AREA (SQ. FT.)	DECK AREA (SQ. FT.)
	36"	30"	14"		
TEMPORARY SOUTH TRESTLE	64			452	30,500

ESTIMATED QUANTITY IN NYSDEC TIDAL WETLANDS ADJACENT AREA

	DIAMETER PILES			PILE AREA (SQ. FT.)	DECK AREA (SQ. FT.)
	36"	30"	14"		
TEMPORARY SOUTH TRESTLE	7			49	220

TAPPAN ZEE BRIDGE
HUDSON RIVER, MILEPOINT 27
SOUTH NYACK-TARRYTOWN, NEW YORK
ROCKLAND AND WESTCHESTER COUNTIES

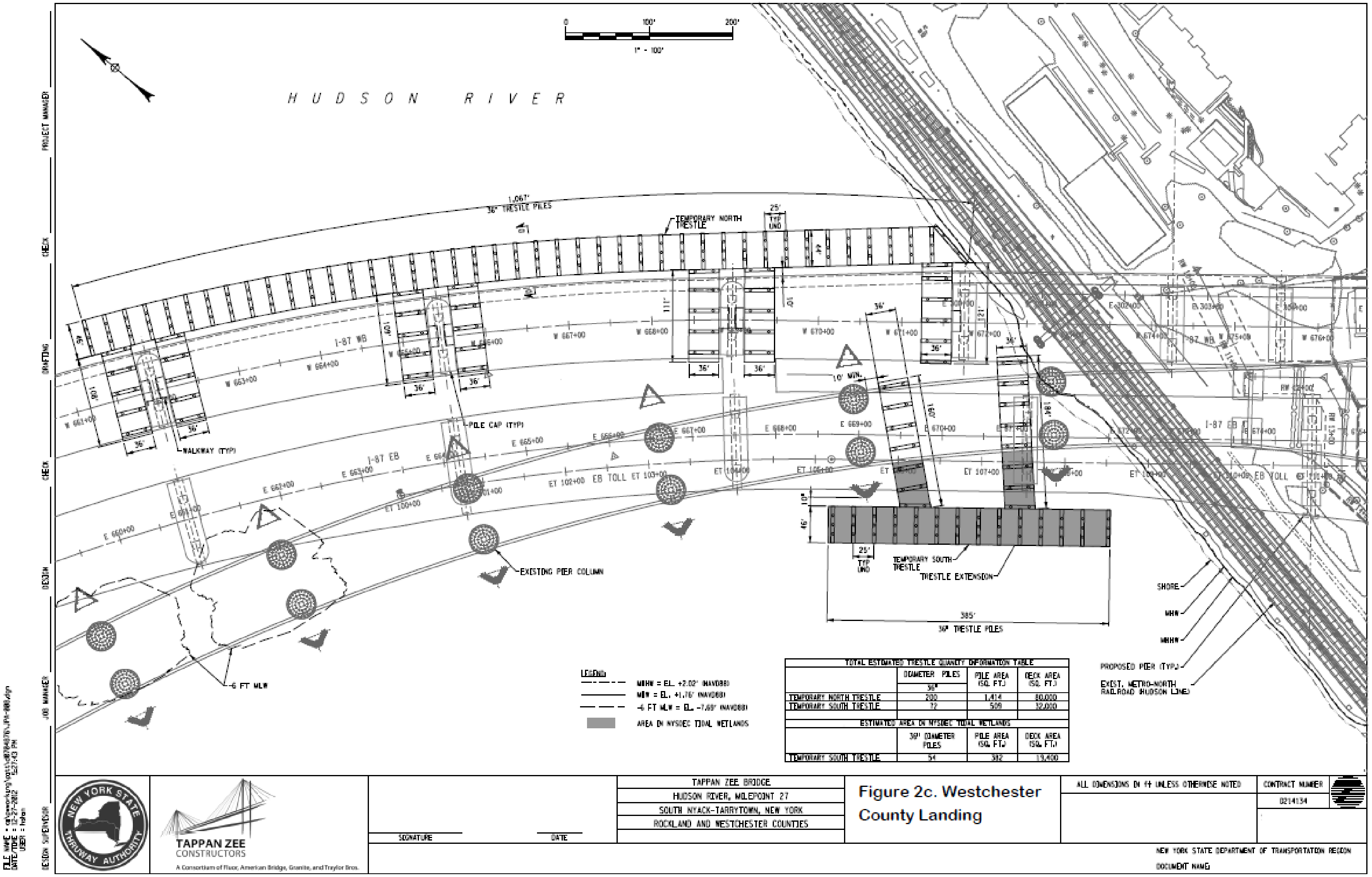
Figure 2b. Rockland County Landing

ALL DIMENSIONS IN ft UNLESS OTHERWISE NOTED

CONTRACT NUMBER
D214134

NEW YORK STATE DEPARTMENT OF TRANSPORTATION REGION 08
DOCUMENT NAME:

Figure 2c. Westchester County Landing



TOTAL ESTIMATED TRESTLE QUANTITY INFORMATION TABLE

	DIAMETER PILES 36"	PILE AREA (SQ. FT.)	DECK AREA (SQ. FT.)
TEMPORARY NORTH TRESTLE	200	1,414	80,000
TEMPORARY SOUTH TRESTLE	72	509	32,000

ESTIMATED AREA IN NYSDEC TIDAL WETLANDS

	36" DIAMETER PILES	PILE AREA (SQ. FT.)	DECK AREA (SQ. FT.)
TEMPORARY SOUTH TRESTLE	54	382	19,400

3.3 Required Environmental Performance Commitments

FHWA will require that certain Environmental Performance Commitments (EPCs) be employed during construction of the substructure. These requirements are part of the contracts with TZC and include:

- 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 4-ft in diameter or greater[2].
- Maintaining a corridor where the sound level is below 150 dB re 1uPa^2·s RMS[3] totaling at least 5,000-ft at all times during impact hammer pile driving. This corridor shall be continuous to the maximum extent possible but at no point shall any contributing section be smaller than 1,500 ft. 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 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.

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[2] FHWA is not requiring noise attenuation for impact pile driving of two-foot and three-foot diameter 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 three-foot bridge piles) and the small isopleth size for the 206 dB peak sound pressure level (less than 50 feet from the pile). Together, these factors minimize the spatial and temporal extent of underwater noise such that the effects of noise attenuation are minimal.

[3] Please note in previous versions of this Opinion, the EPC incorrectly listed the criteria as 187 dB cSEL.

- Armoring of the channel to prevent re-suspension of sediment during the movement of construction vessels.

3.4 Construction of the new bridge

The total project construction time is approximately five years. Construction began in the summer 2013, and is anticipated to be completed by November 2018. 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 will 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 was scheduled to occur in two stages between August 1 and November 1; the first stage of dredging was completed in 2013 and the second completed in 2015. Construction of the main span will consist of approximately four years of construction; this began in the summer of 2013 and it is continuing. Demolition of the existing Tappan Zee Bridge is expected to take approximately 1½ years; it will not commence until after the new bridge is complete.

Several components of construction have already been completed. These components include:

- dredging of the access channel;
- dredging and trestle construction in the Coeymans Staging Area;
- driving of piles 3 to 6 feet in diameter to support the bridge superstructure; and,
- armoring of the river bottom within the access channel.

The remaining construction activities include the construction of temporary and permanent platforms along the shoreline and the construction of the bridge superstructure. Demolition of the existing Tappan Zee Bridge will begin after the new bridge has been opened to traffic.

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 new Tappan Zee Bridge as well as provide a heavy duty trestle for access to the shallow water piers. 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, were installed to facilitate construction of the bridge and to minimize the area and volume of sediment that was dredged from the river bottom to allow access to the shallowest areas of the construction site nearest the shorelines. Pile driving for the Westchester temporary trestle began in 2013. As of April 19, 2016, the Westchester temporary trestle has had 280 of 344 (81%) two-foot piles driven. The remaining 64 piles will be used to complete the construction of the Westchester temporary trestle and/or for falsework in summer 2017.

The North and South Rockland trestles and permanent platform, when completed, will have a total of 348 three-foot piles.

- 143 are for the Rockland permanent platform. As of April 19, 2016, 78 three-foot piles (54%) had been driven.

- 99 are for the temporary North trestle. As of April 19, 2016, all 99 three-foot piles (100%) had been driven for the North Rockland temporary trestle.
- 106 are for the temporary South trestle and/or falsework piles.

Pile driving to complete the Rockland permanent platform will commence in Summer 2016. To complete the Rockland permanent platform, 65 three-foot piles will be driven for bents, landings, and slips. In addition, TZC will install 6 two-foot piles for landings and slips. Installation of approximately 106 three-foot piles for the Rockland south temporary trestle and falsework, as needed, are scheduled to commence in summer 2016. All of these 3-foot piles will be installed primarily with a vibratory hammer, but an impact hammer (~200,000 foot-pounds) will be required for final seating of the piles. The impact hammer will be used for 5-10 minutes for each pile, but may require additional drive times to meet driving criteria's based on sub-surface conditions.

The primary changes to pile installation considered in the September 2014 Opinion (see Table 12 in that Opinion) are summarized below:

- 20 three-foot diameter piles were added that were driven for falsework for the purpose of steel erection between piers 1 through 4 westbound.
- 12 three-foot diameter piles will be driven for the purposes of steel erection for Pier 2 eastbound in June 2016.
- The 44 three-foot piles to be impact driven at Piers 41EB and 42EB were removed as they will be replaced by piles installed in drilled shafts which do not require impact driving.

As of April 19, 2016, there are 343 2-foot and 3-foot steel piles remaining to be impact driven compared to the 361 2-foot and 3-foot piles listed in Table 12 of the September 2014 Biological Opinion.

3.4.2 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. No in-water work, other than the operation of project related vessels and the installation of a limited amount of falsework[4] will be required for the construction of the bridge superstructure.

3.4.3 Concrete Cooling System

Thermal control of concrete can be accomplished through a variety and combination of methods, such as precooling of the concrete, cooling pipe installation and operation, and insulation and temperature monitoring equipment. The size (thickness) of the mass concrete placements required for the Tappan Zee Bridge pile cap and main span tower legs necessitates the use of exterior thermal insulation, interior cooling pipe installation, and temperature monitoring. The cooling system capacity and configuration varies by location (e.g., Main Span, Approach Span)

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[4] Falsework involves pile installation; all of these piles are accounted for in Table 8.

but generally consists of multiple 3/4-in. or 1-in. diameter plastic pipes (composed of PEX, schedule 40 PVC, or pressure-rated polyethylene) embedded 2-4 feet on-center within the interior of the concrete pour.

At both Main Span and Approach locations, a submersible pump, control valve and manifold system will withdraw river water through a cylindrical screen with 6 x 6 mm wedge wire mesh located approximately 2-3 feet below mean low water (MLW). The intake screen of the pump has a 10" diameter. The pump will be surrounded with 2mm mesh. System flows are designed to achieve a temperature rise (ΔT) of the water within the cooling system and discharge water no more than 3 degrees Fahrenheit (°F) (1.65°C) above ambient through the return pipes located one foot below the surface. At Approach Span, Main Span Pile Caps and Main Span Anchor Piers, the individual return pipes will discharge directly to the river. At the Main Span Tower Leg locations, the individual return pipes will be combined into a single 4-in. diameter pipe or hose prior to discharge to the river due to the height of the system above the water surface (up to 60 feet or more above the water surface).

Up to two Approach Span locations (e.g., WB and EB at same pier) and one Main Span location (e.g., Main Span Tower Leg) may be cooled simultaneously; however, this would not occur regularly due to other construction schedule constraints. Use of a once-through cooling system is not anticipated at landside bridge abutments or piers (i.e., P1, P43), or piers located in very shallow water (i.e., P2).

3.5 Existing Bridge Demolition

The majority of 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 approximately 1,000 feet. 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.

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).

3.6 Mitigation required pursuant to the NYSDEC permit

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.

3.7 Vessel Traffic

Numerous vessels are required for the construction of the new Tappan Zee Bridge (Table 1). Except for the barge transits from the Port of Coeymans (see below), project vessel activity typically occurs between Petersen's Marina, two miles upstream of the Bridge, and the Project's mooring field in the Regulated Navigation Area, which extends 1.25 miles downstream of the Bridge (Figure 3). Activity is further concentrated within the regulated navigation area that extends from 500 yards upstream of the bridge to 500 yards downstream of the bridge (approximately 4.5 square kilometers), and within the designated safety zone, an approximately six square kilometer area on the western side of the river where all recreational traffic is prohibited. Occasional vessel transits occur between Haverstraw, Tompkins Cove, and the bridge construction site.

The construction of the new Tappan Zee Bridge will involve the use of 156 project-related vessels in the Hudson River. Of these, 40 (39 project vessels and one contracted tugboat) have propellers; the rest are work barges that are maneuvered using project tugboats. Twenty-three of the 40 vessels are slow moving tugboats and intermittently used work skiffs, whereas 17 are smaller delivery and crew boats that generally operate at higher speeds. More information on vessel speed is provided below. Eleven of the twelve project tugboats draft three feet when unloaded and six feet when loaded. The twelfth tugboat drafts nine feet when loaded. All other vessels (i.e., crew boats, delivery boats, work skiffs) draft two to four feet.

Figure 3. The approximate areas of concentrated vessel activity associated with the Tappan Zee Bridge replacement project.

Table 1. Information on project-related vessels that have propellers.

Vessel Type	Number	Size (ft)	Draft (ft)	Operating Speed (knots)	Max Speed (knots)
Project tugboat	12	25 – 65	3 - 9	4 – 5	10
Contract tugboat*	1	107	13	6 - 10	12
Small Crew Boat	8	25	3	15 - 25	35
Large Crew Boat	7	36 - 50	4	15 - 20	26
Delivery Boat	2	32	4	15	15
Work Skiff	10	20	2	2	2

*12 of the 13 are project vessels. The remaining tug is a contracted vessel that transits the river between the Port of Coeymans and the Tappan Zee Bridge.

The FHWA has estimated the amount of vessel traffic that will occur between April 2016 and November 2018, when construction is anticipated to end. They estimate that project tugboats will operate for a total of 90,440 hours (excluding the trips to Coeymans, discussed below), and will generally operate between 4 and 5 knots. This equates to a 3-year average of 30,147 hours per year. The crew boats are anticipated to operate for 106,500 hours, which equates to a 3-year average of 35,500 hours per year, and will generally operate between 15 and 25 knots.

A contracted tug boat working for TZC transports steel girder assemblies from the Port of Coeymans to the construction site at the Tappan Zee Bridge (175 kilometers) two to three times a week. Using AIS data from three downstream trips, the average speed of a typical contracted tug during transit between the Port of Coeymans and the Tappan Zee Bridge was determined to be 8.2 knots (range: 0.7 to 11.4 knots); the average speed through Haverstraw Bay to the Tappan Zee Bridge (from 19 measurements) was also 8.2 knots (range: 4.8 to 10.8 knots). The tug travels at speeds of six to eight knots during approximately 33% of the trip from Coeymans, eight to ten knots during 58% of the trip, ten to eleven knots during 5% of the trip, and less than six knots during 4% of the trip.

During tows between Coeymans and the construction site, the tug operates within the Federal navigation channel, where depths are between 30 and 40 feet, and adheres to United State Coast Guard Navigation Rules for International-Inland while in transit. FHWA submitted additional information to us on April 21, 2016, which indicates that 95 round trips still need to be completed between the project site and the staging area. Of these, 80 will occur between April 21, 2016 and November 30, 2016, while the remaining 15 trips will occur in 2017. At 24 hours per trip, it is anticipated that this tug will operate for 1,920 hours in 2016, and 360 in 2017.

3.8 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. The action area also includes the area where in-water work will be carried out at Coeymans and extends to the area of the river where increased underwater noise levels and changes in water quality will result from that work, as described in the Effects of the Action section below. The action area also includes the route traveled by tug/barges from New York City to Coeymans and from Coeymans to the bridge site. The action area also includes the area where crew boats and delivery boats are active. All vessels will travel within the Hudson River Federal navigation channel, or in the shallow areas within two miles of the bridge. We anticipate that all effects of the action will occur within this geographic area. See Figure 1 for a map of the bridge location.

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)[5] when the freshwater temperatures increase to 8-9ºC. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987; Crowder *et al.* 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

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[5] 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.

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). Snyder (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)[6] 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 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

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[6] 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.

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.

4.1.1 Shortnose Sturgeon in the Hudson River

The action area is limited to the reach of the Hudson River from New York Harbor to Coeymans, NY, 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.

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 (ASA 1999-2002; Dynegy 2003) suggesting that the range of shortnose sturgeon is extending downstream. Shortnose sturgeon were documented as far south as the Manhattan/Staten Island area in June, November and December 2003 (Dynegy 2003).

From late fall to early spring, adult shortnose sturgeon concentrate in a few overwintering areas. Reproductive activity the following spring determines overwintering behavior. The largest overwintering area is just south of Kingston, NY, near Esopus Meadows (RM 86-94, rkm 139-152) (Dovel *et al.* 1992). The fish overwintering at Esopus Meadows are mainly spawning adults. Recent capture data suggests that these areas may be expanding (Hudson River 1999-2002, Dynegy 2003). Captures of shortnose sturgeon during the fall and winter from Saugerties to Hyde Park (greater Kingston reach), indicate that additional smaller overwintering areas may be present (Geoghegan *et al.* 1992). Both Geoghegan *et al.* (1992) and Dovel *et al.* (1992) also confirmed an overwintering site in the Croton-Haverstraw Bay area (RM 33.5 – 38,rkm 54-61). The Tappan Zee Bridge is located approximately 11km (6 miles) south of the southern extent of this overwintering area, which is near rkm 54 (RM 33.5). Fish overwintering in areas below Esopus Meadows are mainly thought to be pre-spawning adults. Typically, movements during overwintering periods are localized and fairly sedentary.

In the Hudson River, males usually spawn at approximately 3-5 years of age while females spawn at approximately 6-10 years of age (Dadswell *et al.* 1984; Bain *et al.* 1998). Males may spawn annually once mature and females typically spawn every 3 years (Dovel *et al.* 1992).

Mature males feed only sporadically prior to the spawning migration, while females do not feed at all in the months prior to spawning.

In approximately late March through mid-April, when water temperatures are sustained at 8º-9° C (46.4-48.2°F) for several days[7], 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 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

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[7] 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.

1998), typically in late November[8]. Juveniles are distributed throughout the mid-river region during the summer and move back into the Haverstraw Bay region during the late fall (Bain *et al.* 1998; Geoghegan *et al.* 1992; Haley 1998).

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

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

4.2 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

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[8] 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.

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.

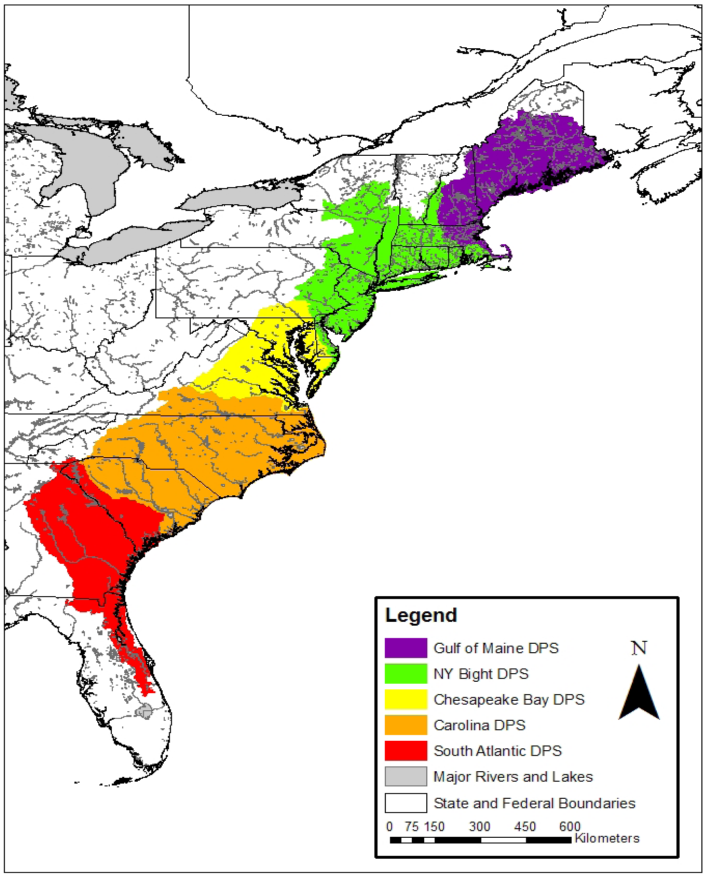
The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered, and the Gulf of Maine DPS is listed as threatened (77 FR 5880 and 77 FR 5914, February 6, 2012). The effective date of the listings was April 6, 2012. The DPSs do not include Atlantic sturgeon spawned in Canadian 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[9] 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).

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[9] 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)

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 subadults or 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 2. 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 include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007).

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011).

The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (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.

4.2.3 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 3). 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[10], and federal fishery discard estimates from 2006 to 2010 to produce a virtual population.

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[10] 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.

In additional to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 4). 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 3. Description of the ASPI model and NEAMAP survey based area estimate method.

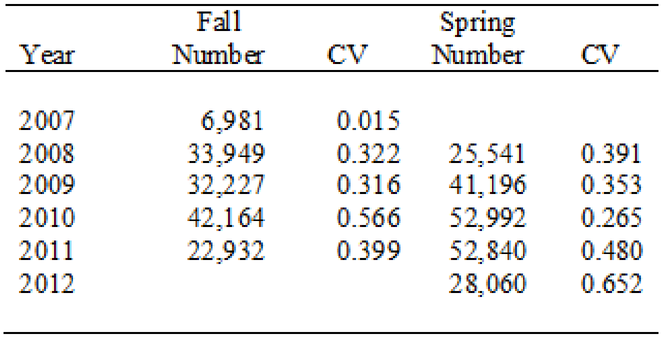
Model Name	Model Description
A. ASPI	Uses tag-based estimates of recapture probabilities from 1999 to 2009. Natural mortality based on Kahnle *et al.* (2007) rather than estimates derived from tagging model. Tag recaptures from commercial fisheries are adjusted for non-reporting based on recaptures from 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 4. 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

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 5). 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 5. 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 4). 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 6) 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 2017. NMFS will be partnering with them to conduct the stock assessment, and the ocean population abundance estimates produced by the NEFSC will be shared with the stock assessment committee for consideration in the stock assessment.

Table 6. 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

*As discussed on page 145, genetic testing conducted on Atlantic sturgeon sampled by the NEFOP indicates that approximately 91% of the NYB Atlantic Sturgeon originate from the Hudson River.

4.2.4 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 19th and 20th 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%.

4.3 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 17th century (Squiers *et al.* 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.* 1979). Following the 1880's, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by-catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

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

4.4 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. A decline in the abundance of young Atlantic sturgeon 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). At the time of listing, catch-per-unit-effort (CPUE) data suggested that recruitment 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 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. Standardized mean catch per net set from the NYSDEC juvenile Atlantic sturgeon survey have had a general increasing trend from 2006 – 2015, with the exception of a dip in 2013.

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. Recent information from surveys of juveniles (see above) indicates that the number of young Atlantic sturgeon in the Hudson River is increasing compared to recent years, but is still low compared to the 1970s. There is currently not enough information regarding any life stage to establish a trend for the entire 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. Additionally, 138 sturgeon carcasses were observed on the Hudson River and reported to the NYSDEC between 2007 and 2015. Of these, 69 are suspected of having been killed by vessel strike. Genetic analysis has not been completed on any of these individuals to date, given that the majority of Atlantic sturgeon in the Hudson River belong to the New York Bight DPS, we assume that the majority of the dead sturgeon reported to NYSDEC belonged to the New York Bight DPS. Given the time of year in which the fish were observed (predominantly May through July), it is likely that many of the adults were migrating through the river to the spawning grounds.

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.

4.5 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.

4.6 Atlantic sturgeon in the Hudson River

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 likely 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. We also include a summary of impacts of the Tappan Zee Bridge replacement project as completed through March 2016.

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[11] in 2007 (#1580, originally issued as #1254) to evaluate the life history, population trends, and spatio-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

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

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

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 seven steel piles, clustered at four locations across the Hudson River, immediately to the north of the existing Tappan Zee Bridge. Additionally, approximately 75 small ancillary piles (1- to 2-foot diameter) were 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 7 test piles to be driven by an impact hammer; and,
- A total of no more than 19 Atlantic sturgeon injured during the installation of the 7 test piles to be driven by an impact hammer. Based on mixed stock analyses, we anticipate that no more than 1 of the Atlantic sturgeon will be GOM DPS origin and no more than 1 will be Chesapeake Bay DPS origin. The remaining 17 Atlantic sturgeon will be New York Bight DPS origin.

No injured or dead sturgeon were observed during the PIDP. More information on tracking of tagged sturgeon that occurred during the PIDP is included in section 7.2.2 of this Opinion.

5.1.4 Roseton and Danskammer Power Plants

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

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

5.1.5 Indian Point Nuclear Generating Facility

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

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[12] 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.

the wedge wire screens are 6mm x 12.5 mm (0.25 inches by 0.5 inches); eggs are small enough to pass through these openings but are not expected to occur in the immediate vicinity of the Indian Point site.

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

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

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

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

The Indian Point facility may be relicensed in the future; if so, it could operate until 2033 and 2035. NRC is currently considering Entergy’s application for a new operating license. NRC’s proposed action was the subject of a section 7 consultation with NMFS that concluded in October 2011; 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 Units 2 and 3 (Indian Point, IP2 and IP3) 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 at the Unit 1[13] 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 at Unit 2 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.

5.1.7 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 USACE. 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 USACE. 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.

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[13] As explained in the Opinion, water withdrawn through the Unit 1 intakes is used for service water for the operation of IP2.

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 Vessel Traffic in the Hudson River

The Hudson River is navigable from the New York Harbor to north of Albany and serves both recreational and commercial boaters. Between 2000 and 2008, annual vessel traffic under the Tappan Zee Bridge ranged from 8,000 to 16,000 vessel movements per year (excluding small recreational boats) (FHWA 2012).

A wide variety of materials are shipped via the Hudson River. Several large ports and marine terminals exist along the river, including those in Albany, Coeymans, Newburgh, Yonkers and Red Hook. The USACE Navigation Data Center[14] reports that for calendar year 2009 – calendar year 2013, the number of commercial vessel trips (inclusive of both upriver and downriver trips) in the river (from confluence of Hudson with Harlem River to Waterford, NY) ranged from a high of 17,543 trips in 2009 to a low of 14,177 in 2012. This includes domestic and international vessels inclusive of self-propelled dry cargo, self-propelled tanker, self-propelled towboat, non-self-propelled dry cargo and non-self-propelled liquid tanker barge. The portion of these vessels operating in the action area is unknown; however, any of these vessels that are transiting to or from marine terminals upstream of the Tappan Zee Bridge, including Albany, would transit through the action area. Vessel drafts ranged from 0-38 feet with the vast majority in the 6-9 foot range.

In late 2011, crude oil (Bakken oil) from North Dakota began being shipped via rail car to the Port of Albany. The crude oil is then shipped via tankers and barges down the Hudson River from the Port of Albany to refineries along the U.S. East Coast. The number of self-propelled

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[14] USACE Navigation Data Center, Waterborne Commerce Statistics Center. Trips by Waterways. Hudson River (Sheet 104). http://www.navigationdatacenter.us/wcsc/webpub13/Part1_WWYs_Trips_VessType_YR_Dir_Draft_CY2013_CY2009.htm. Last Accessed April 10, 2016.

tanker and non-self propelled tanker liquid barge shipments from Albany increased from 2011 to 2014[15] (560 in 2011, 685 in 2012, and 943 in 2013, and 1,249 in 2014). The vessels that transport crude oil in the Hudson River have relatively deep drafts (i.e., 20 to 38 feet). The number of self-propelled tanker and non-self propelled tanker liquid barge shipments from Albany with drafts greater than 20 feet has increased from 15 in 2009 to 343 in 2014 (the most recent year that data is available).We do not have information to determine the percent of these vessels that were transporting crude oil; however, in 2012 Global Partners received permission from New York state to increase shipments of crude oil from 900 million gallons to 1.8 billion gallons annually. Also in 2012, Buckeye received permission to increase shipments of crude oil from 400,000 gallons to 1 billion gallons. The Global Partners and Buckeye terminals are in Albany and shipments of crude oil from these facilities is thought to contribute to this increase in deep draft liquid transport vessels transiting downriver from Albany.

In addition to commercial cargo transport, a number of ferries operate in the action area, crossing the river at least daily. Some of these services are year-round and others are seasonal. The Hudson River is also used by sail boats, power boats, and other personal water craft users for recreational purposes. An estimate of the number of recreational vessels in the Hudson River generally or in the action area is not available.

In 2007, NYSDEC began maintaining records of dead sturgeon reported by the public and others. Through January 2016, there have been 139 dead sturgeon (mostly Atlantic sturgeon) reported to NYSDEC within the Hudson River. Of these, the majority (115 out of 139) were observed between 2013 and 2015. The majority of sturgeon mortalities (76 of 115) since 2013 have been Atlantic sturgeon; 52 of which were assumed to have been killed by vessel strike (based on the type of injury observed). Relatively few (23 of 115) of the mortalities reported since 2013 were shortnose sturgeon and very few (4) of those were determined to be vessel related. Species was not determined for 16 of the reported carcasses. Of these, three were determined to be vessel-related mortalities. Not all of these dead sturgeon were reported from the action area; however, given the state of decomposition of many of them as well as the tidal currents in the river, it is not possible to determine the exact location of death and we cannot precisely estimate the portion of total mortalities reported in the Hudson River that were killed in the action area.

It is important to note that with the exception of monitoring required by our Biological Opinions, the approach to monitoring for dead sturgeon in the Hudson River has been opportunistic, and has not involved a systematic strategy for surveying and recording occurrences. Additionally, very few of the carcasses have been examined by an expert and the cause of death is based only on injury type (e.g., large gashes and or decapitation is assumed to be caused by pre-mortem vessel strike). Prior to 2011, there was minimal awareness that vessel strike constituted a threat to sturgeon in the Hudson River. According to the NYSDEC, record keeping became more

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[15] USACE Navigation Data Center, Waterborne Commerce Statistics Center. Trips by Port (Albany - Sheet 1). http://www.navigationdatacenter.us/wcsc/webpub13/Part1_Ports_Trips_VessType_YR_Dir_Draft_CY2013_CY2009.htmLast Accessed April 10, 2016. 2014 data was provided to NYSTA by the USACE and transmitted to NMFS on May 31, 2016.

intensive around 2011-2012 as a result of the recognition that Atlantic sturgeon on the Delaware River were being struck by large commercial vessels. From 2007-2011, the NYSDEC recorded four specific types of information when a sturgeon mortality was reported: date, observer contact, location of the sturgeon, and condition of the sturgeon. Sturgeon species was not specifically recorded, nor was the suspected cause of death. Beginning in 2012, a more comprehensive record keeping program was initiated by NYSDEC to document sturgeon mortalities in the Hudson River. At this point, they began recording approximately 12 specific types of information for each reported mortality, including sturgeon ID number, species, date, contact information, location, photo documentation, body length, condition, disposition following the sighting, possible vessel strike, if the sturgeon was scanned for ID tags and painted, and other relevant comments.

As observations have been opportunistic, monitoring effort has not been consistent year to year or from place to place. It is reasonable to assume that the listing of Atlantic sturgeon under the ESA in 2012 and the publicity associated with the construction of the new Tappan Zee Bridge led to increased public awareness in possible threats to the species. Additionally, Hudson Riverkeeper posted information on its website in 2012 and again in 2013 and the Thruway Authority distributed pamphlets and posted signage in 2014 to encourage public reporting. All of these public outreach efforts have likely contributed to the increased number of reports since 2012.

The observations of dead sturgeon to-date have been invaluable in identifying vessel strike as a threat to shortnose and Atlantic sturgeon in the Hudson River. However, the inconsistent monitoring effort over time and river reach and opportunistic nature of the majority of reports, makes it difficult to draw conclusions about how, when and where these sturgeon were killed. The NYSDEC database reflects the minimum number killed, and without a standardized sampling effort it is not possible to estimate the total number of dead sturgeon in the river, or to compare one river reach to another. However, it is clear that sturgeon are being killed by vessels in the Hudson River. While overall commercial vessel traffic in the Hudson River has not increased, the amount of deep draft (>20 feet) commercial vessel traffic in the Hudson River (and presumably the action area) has more than doubled from 2009 – 2014. If deep draft vessels pose an increased risk to sturgeon compared to shallower draft vessels, the risk of vessel strike could have increased during this time period despite an overall reduction in the amount of commercial vessel traffic. Without information to the contrary, we assume that the baseline risk of vessel strike is the same now as it was in 2013 and 2014.

5.2.3 State Authorized Fisheries

Atlantic and shortnose sturgeon are 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, including NY, 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).

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 undulatus*) 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.

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 February 2010, ASMFC adopted Amendment 3 to the ISFMP for Shad and River Herring, which establishes a coastwide commercial and recreational moratorium, with exceptions for sustainable systems. The American shad fishery in the Hudson River has been closed since 2010; in the past this fishery was known to capture Atlantic and shortnose sturgeon. Commercial fishing for river herring is prohibited in the Hudson River. Recreational catch (limit of 10 fish per day by hook and line or personal net) is allowed in several counties in the mainstem Hudson between March 15 and June 15. Interaction rates with shortnose and Atlantic sturgeon are unknown.

Striped bass

Fishing for striped bass occurs within the Hudson River. 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 IV (October 2014), the coastwide striped bass quota has been reduced. NYSDEC enacted emergency striped bass regulations in March 2015; these limit catch to one striped bass per day. 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.

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

5.4.1 Shortnose and Atlantic sturgeon at the Coeymans staging area

Shortnose sturgeon occur in the Coeymans reach during the spring spawning period. In approximately late March through mid-April, when water temperatures are sustained at 8º-9° C (46.4-48.2°F) for several days[16], reproductively active adults begin their migration upstream to the spawning grounds that extend from below the Federal Dam at Troy to about Coeymans, NY (RM 152-131) (Dovel *et al.* 1992)). Spawning typically occurs at water temperatures between 10 and 18°C (50-64.4°F) after which adults disperse quickly down river into their summer range. In the Hudson River, temperatures (as measured at the USGS gage in Albany) are typically between 8 and 18°C for a 4-6 week period between early April and late May each year. Dovel *et al.* (1992) reported that spawning fish tagged at Troy were recaptured in Haverstraw Bay (RM 34-

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[16] USGS gage in Albany (gage no. 01359139). Information available at: http://waterdata.usgs.gov/usa/nwis/uv?01359139

40) in early June.

Shortnose sturgeon eggs adhere to solid objects on the river bottom (Buckley and Kynard 1981; Taubert 1980). Eggs and larvae are expected to remain within the vicinity of the spawning grounds for approximately four weeks post spawning (i.e., at latest through mid-June). Larvae gradually disperse downstream after hatching, entering the tidal river (Hoff *et al.* 1988) and concentrating in deep channel habitat (Taubert and Dadswell 1980; Bath *et al.* 1981; Kieffer and Kynard 1993; Dovel *et al.* 1992).

Based on the best available data, we expect adult shortnose sturgeon to occur near Coeymans during the spawning period. Depending on annual variations in water temperature, adults are expected in this area for a 4-6 week period between early April and late-May. We expect early life stages to be present in the action area for approximately four weeks after spawning ends. Therefore, we expect early life stages near Coeymans from late April through June.

In April 2014, NMFS received information from researchers working in the Hudson River which, through detection of tagged individuals on a receiver array, confirms the presence of adult Atlantic sturgeon upstream of RM 120 from late April – early July (Dewayne Fox, DSU and Kathy Hattala, NYSDEC, personal communication April 2014). At this time the available data are limited to three fish comprised of two males in spawning condition and an assumed male. However, given the time of year, the reproductive conditions of the fish, and the known presence of suitable spawning substrate upstream of RM 120, this strongly suggests that Atlantic sturgeon are spawning further upstream than previously suspected. Two of the fish had moved downstream past RM 95 by June 15 while the other remained above RM 95 until late July.

Based on the best available data, we expect adult Atlantic sturgeon to occur near Coeymans between late April and early July. We expect early life stages to be present in the area for approximately four weeks after spawning ends. Therefore, we expect early life stages from late April through the end of July, after which larvae will be further downstream. We expect all Atlantic sturgeon in this area to have originated from the New York Bight DPS.

5.4.2 Shortnose and Atlantic sturgeon near the Tappan Zee bridge construction site

As discussed in the life history sections above, spawning sites for Atlantic and shortnose sturgeon are located outside of the Tappan Zee bridge replacement construction 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 at the new bridge site.

Atlantic sturgeon adults are likely to migrate through the portion of the action area where bridge 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 new bridge 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 Tappan Zee 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^oC (5^o-9^oF) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2^oC (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^{o}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 affect 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.

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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 by the proposed action and are later in time, but are still reasonably certain to occur. As explained in the Consultation History section, this consultation has been reinitiated a number of times. In this Opinion, we consider the likely effects of the action and any interrelated and interdependent actions that have not yet been completed 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.

The activities that are not yet complete have the potential to affect shortnose and Atlantic sturgeon in several ways: 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 include a summary of impacts of the Tappan Zee Bridge replacement project as completed through March 2016. These effects are also factored into the Integration and Synthesis of Effects (Section 9) as section 7(a)(2) of the ESA applies to the action as a whole, and not just the components that have not been completed as of the reinitiation date.

7.1. Bridge Replacement Activities Completed to Date

A number of activities considered in earlier Opinions on the effects of the replacement of the Tappan Zee Bridge have been completed. This includes dredging the access channel, armoring the river bottom, and the installation of 1,558 piles (through December 29, 2015) including all 4, 6 and 8' diameter piles, and hundreds of 2 and 3' trestle piles. Observer coverage allowed for 100% monitoring of all dredged material removed from the River in 2013 and 2015; no sturgeon were observed during dredging. Thus, while previous Opinions included an Incidental Take Statement exempting take of shortnose and Atlantic sturgeon during dredging, no take occurred. In previous Opinions, we included an ITS exempting the take of shortnose and Atlantic sturgeon due to exposure to pile driving noise that was expected to result in physiological effects. Based on acoustic monitoring completed through December 29, 2015, eight shortnose sturgeon and eight Atlantic sturgeon have been exposed to noise during pile driving that likely resulted in physiological effects (TZC Monthly Pile Driving Report November 29, 2015 – December 29, 2015). This is a smaller number than anticipated in previous Opinions, due to the models used to predict pile driving noise and duration of pile driving overestimating actual conditions.

A monitoring protocol for sturgeon was in place during the installation of piles four feet and greater in diameter. As detailed below, three “fresh-dead” sturgeon (two shortnose and one Atlantic) and one injured shortnose sturgeon (later died) have been collected from the action area by the project team that were in condition suitable for necropsy. A dead shortnose sturgeon collected on May 15, 2014, had no evidence of barotrauma. In the necropsy report, Cornell (2014a) stated that “the injury does not appear to be due to a ship strike or propeller impacts” but that it was not possible to “completely rule out that the traumatic injury was caused by a ship strike. One would expect that a boat propeller would leave multiple cuts/wounds…Multiple cuts/wounds were not present. It is not likely that a strike by a boat hull would result in a clean decapitation of the fish. Also, in the case of a strike from a boat hull, one would expect significant wounds and abrasions to the body. Multiple wounds and abrasions were not present.” However, we note that Brown and Murphy (2010) conclude that Atlantic sturgeon severed through the torso or head region as indicative of being entrained through the propeller of a large vessel. Another possibility is that the sturgeon was beheaded by a predator; the only predators in the Hudson River that could cause this type of damage is a seal. We do not know enough about predation by seals to determine if beheading is typical. Considering the information in Brown and Murphy and the uncertainty in the necropsy conclusions, it is reasonable to conclude that vessel strike could be the cause of death for the shortnose sturgeon collected on May 15, 2014.

A dead shortnose sturgeon collected on October 24, 2014 had no internal or external injuries (other than those caused by scavengers) and no cause of death could be determined (Cornell 2014b). The cause of death of an Atlantic sturgeon collected on June 4, 2015 was determined to be due to massive lesion at the peduncle which would have caused tail paralysis and massive bleeding. Due to the torn muscles and severed spinal cord, vessel interaction was identified as “one possibility” for the cause of death (Cornell 2015a). A live injured shortnose sturgeon was collected on August 13, 2015; the fish died that night. Necropsy found a number of external injuries and a prolapsed lower intestine and concluded that the cause of death was a strike by something blunt “like the bow of a boat” (Cornell 2015b).

The vessels responsible for the three presumed vessel strikes are unknown; we report them here because the Tappan Zee project team collected the fish and sent them for necropsy.

7.2 Pile Driving

7.2.1 Pile Installation at the Tappan Zee bridge site

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 to help inform the analysis. 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 and installation of permanent bridge piles have been completed. Through December 29, 2015, 1,558 piles were installed. Acoustic monitoring conducted during pile installation indicates that eight shortnose sturgeon and eight Atlantic sturgeon were exposed to noise that would result in minor injuries. Three dead and one injured sturgeon have been collected by the project team near the bridge site; necropsies conducted on these fish did not indicate any damage to tissues that could be attributable to exposure to increased underwater noise or pressure (i.e., barotrauma). The project team is monitoring the use of the area with acoustic receivers which detect the presence of sturgeon carrying acoustic tags. Shortnose sturgeon were detected in all months. Atlantic sturgeon were detected in all months except December, January and February.

7.2.2 Information Used to Conduct the Effects Analysis

7.2.2.1 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 1µPa^2-s.

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

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

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

7.2.2.2 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 two 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 cSEL) 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 hogchoker 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 cSEL ranging from 216 dB re 1µPa^2-s to 204 dB re 1µPa^2-s. 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 1µPa^2-s. 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.

7.2.2.3 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 µPa^2·s cSEL. Smaller injuries, such as ruptured capillaries near the fins, which the authors noted were not expected to impact fitness, occurred at lower noise levels. The peak noise level that resulted in physiological effects was about the same as the FHWG criteria.

Based on the available information, for the purposes of this Opinion, we consider the potential for physiological effects upon exposure to 206dB re 1 µPa peak and 187 dB re 1 µPa^2-s cSEL.

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

7.2.2.4 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 eight or ten 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 re 1 µPa RMS 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.

In the 2014 BA, FHWA noted that 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.

7.2.3 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 seven steel piles, clustered at four locations across the Hudson River, immediately to the north of the existing Tappan Zee Bridge. Additionally, approximately 75 small ancillary piles (1- to 2-foot diameter) were installed. The four locations were selected to represent distinct geological stratigraphies encountered along the approximately three-mile span of the crossing alignment.

Four 4-foot diameter piles were installed in the deeper sediments on the west side of the river channel. A 4-foot and an 8-foot diameter pile were each installed on the west side of the navigation channel where thin sediment overlies sandstone. One 10-foot pile was installed on the east 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 75 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 typically of 150 foot length and an upper section of up to 150 foot length. 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 (draft < 5 feet) vessels were used for personnel movements between the workboats. Water depths at the four sites were 9.2 feet, 11.4 feet, 17.7 feet, and 16.6 feet; thus, there was always at least 4 feet of clearance between the vessels and the river bottom.

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. All test piles were cut off at -20 feet or two feet below the mudline, whichever was lower.

During pile driving, sound levels were measured at a range of 33 feet from the test piles and, using autonomous acoustic recorders, at ranges of 1,000–10,000 feet 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 between six and eight feet 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 peak SPL, SPL RMS, and cSEL 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 peak SPL
- 10.8–16.1 dB reduction in SPL RMS
- 9.9–13.7 dB reduction in ssSEL and cSEL

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

In order to detect acoustic-tagged Atlantic sturgeon[17] in the vicinity of pile-driving activities, four VEMCO VR2W acoustic monitoring receivers were deployed equidistant across the river and approximately in line with the pile-driving locations (one receiver on the west side of the river was not recovered; see Figure 12 in JASCO 2012). Each receiver had a detection range of at least 500 meters, within which the presence, identity (tag number) and residence time of individual tagged sturgeon were recorded by the receivers.

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[17] 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.

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).

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 4-foot 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 $\mu Pa^2 \cdot s$ cSEL 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 $\mu Pa^2 \cdot s$ cSEL), 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 $\mu Pa^2 \cdot s$ cSEL. 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 $\mu Pa^2 \cdot s$ cSEL, 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 previous Biological Opinions for this project which assessed the potential for injury using the peak SPL criterion of 206 dB re 1 µPa (rather than the cumulative criterion of 187 dB re 1 $\mu Pa^2 \cdot s$).

7.2.4 Effects of Pile Installation at the Tappan Zee bridge site 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.

7.2.4.1 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 first 150 to 300 feet of the pile will be installed with a vibratory hammer. In your 2014 BA, you indicated 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 cSEL at a distance of 16 feet or the driving of wood piles with an acoustic footprint of 150 dB re 1 μPa^2-s cSEL within 33 feet of the pile being driven (Jones and Stokes, 2009)). In-field monitoring of the installation of a 4-foot diameter pile with a vibratory hammer (TZC 2014) indicates a peak SPL of 158 dB re 1uPa at a distance of 47 feet from the pile; noise decreased to a maximum peak SPL of 148 dB re 1uPa at a distance of 220 feet from the pile and decreased to a peak SPL of 136 dB re 1uPa at 555 feet from the pile. Noise was measured at 150 dB re 1uPa RMS at a distance of 47 feet from the pile and decreased rapidly to 130 dB re 1uPa RMS SPL at 220 feet and 119 dB re 1uPa RMS SPL at a distance of 555 feet from the pile.

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 for piles under 4-feet in diameter (i.e., within 47 feet of the pile being installed), it is extremely unlikely that the behavior of any individual sturgeon would be affected by noise associated with the installation of piles with a vibratory hammer. Even if a sturgeon was within 47 feet 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 47 feet 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.

7.2.4.2 Noise Associated with the Drilling and Pinning of Piles

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 (see 77 FR 23575 and NMFS 2011 Biological Opinion on the Columbia River Crossing). 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.

7.2.4.3 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. The only piles that still need to be installed are 2 and 3 foot diameter trestle support piles. All 4, 6 and 8-foot diameter piles have been installed. An impact hammer will be used for 5-10 minutes for each of the trestle piles (2 and 3 foot) 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.

In-field measurements were made for the installation of two-foot and three-foot trestle piles (see AKRF 2013). A single hydrophone was located ten 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 (5 minutes for 2-foot piles and 10 minutes for 3-foot piles). These time periods are expected to correspond with the amount of impact pile driving necessary to install the 2 and 3 foot trestle piles. The practical spreading loss model was used to calculate cSEL. All calculations were carried out by AKRF and transmitted to NMFS by FHWA.

The table below provides estimates, based on in-river measurements of 2 and 3-foot piles, to the 150 dB re 1µPa RMS, 187dB re: 1µPa^2-s cSEL and 206 dB re 1µPa Peak isopleths. When calculating the distance to the 187dB re: 1µPa^2-s cSEL isopleth, FHWA used the maximum time expected for installation of that size.

Table 7. Approximate Spatial Extent of the 187 dB cSEL, 206 dB Peak, and 150 dB RMS acoustic footprint as measured in distance from the pile being driven

Pile Diameter	Maximum distance from pile to 206 dB re 1µPa peak isopleth (feet)	Maximum distance from pile to 187 dB cSEL isopleth (feet)	Maximum distance from pile to 150-dB rms SPL isopleth (feet)
2 feet (trestle)	38	124	596
3 feet (trestle)	50	169	886

Note: distance is total length in north-south or east-west direction.

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 (FHWA 2013; see Table 8[18], below). 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.

7.2.4.3 Potential for Exposure to Underwater Noise – Pile Installation at Tappan Zee

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 206 dB re 1 µPa peak for a single strike or 187 dB re 1 µPa^2·s for accumulated energy (cSEL) 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 cSEL. Unlike SPL$_{peak}$, cSEL 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, the number of pile strikes needed to install the pile with an impact hammer is typically greater than 1,000. In other words, there is the potential for physiological effects if a sturgeon is within 38 feet of a 2-foot diameter pile for a single pile strike, or if a sturgeon stays within 124 feet of a 2-foot pile for the entire time it is being hammered with the impact hammer (5 minutes). For the 3-foot piles, a

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[18] Table 8 in this Opinion represents similar information that was shown in Table 12 in the September 2014 Opinion

sturgeon would need to be within 50 feet for a single strike or stay within 169 feet of the pile for the entire time it is being hammered with the impact hammer (10 minutes).

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 2-foot pile at the onset of installation, it would need to swim 124 feet before the end of the five minute pile driving time, requiring a swim speed of approximately 0.4 feet per second (fps; 12 cm/s). The furthest distances required would be for the 3-foot piles. FHWA predicts pile driving times of approximately ten minutes; a sturgeon would need to swim at least 169 feet before the 1ten minute pile driving time was completed, requiring a swim speed of approximately 0.3 fps (8.5 cm/s).

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 m/s (1.6-2 fps) with a maximum recorded speed of 2.1 m/s (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/s (0.33-3.0 fps). They report burst swim speeds of 40-70 cm/s (1.3-2.3 fps), prolonged swimming at 15-70 cm/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 0.3 to 0.4 fps for a period of less than 10 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. A soft start method for all impact pile driving.

7.2.4.4 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 (i.e., 38 to 50 feet, depending on the size of the pile). 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. The distance from the pile to the 206 dB re

1 µPa SPL_{peak} isopleth is within 50 feet for the two and three foot piles. Based on the calculated diameters of the ensonified area and the size, number and timing of piles to be driven, FHWA used the sturgeon encounter method (as described in the 2012 BA and 2014 Opinion) to calculate the total number of shortnose sturgeon potentially exposed to peak noise of 206 dB re 1uPa during the entirety of construction. This is presented in Table 8. It was estimated that as many as 37 shortnose sturgeon could be exposed to the effects of pile driving over the duration of the project. Acoustic monitoring carried out through the end of 2015 indicates that rather than 31 shortnose sturgeon (the number expected through the end of 2015), only 8 have been exposed to underwater noise that would result in physiological effects. This is due to peak noise being less than anticipated and isopleths not being as large as anticipated. The installation of piles in 2016 and 2017 is expected to result in the exposure of no more than six shortnose sturgeon to underwater noise that will result in physiological impacts.

As discussed in our 2014 opinion, we cannot rely on the estimates provided in the 2012 BA for the number of juvenile or adult Atlantic sturgeon likely to be exposed to noise levels of 206 dB re 1 µPa peak. However, all available data indicates that there are fewer Atlantic sturgeon in the project area than shortnose sturgeon, and since 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 six over the remainder of the project, the same maximum estimated for shortnose sturgeon.

Table 8. Estimated number of shortnose sturgeon exposed to peak noise of 206 dB re 1uPa for piles remaining to be driven

Year	Start Week	Pile diameter (feet)	Pier	Number of piles	Pile driving time (hours/pile)	Width of isopleth for 206-db SPLpeak(ft)	Number of sturgeon potentially affected by pile driving	Estimate of number of sturgeon exposed to potentially injurious levels of noise
2016	17	3	Pier 2 EB	15	0.33	100	0.13	2
	20	3	Pier 3 EB	15	0.33	100	0.13	
	22	3	Steel Erection Falsework - Pier 2 EB	12	0.33	100	0.10	
	24	3	Pier 4 EB	14	0.33	100	0.12	
	26	3	Rockland South Trestle and Falsework	106	0.33	100	0.92	
	35	3	Pier 40 EB	24	0.33	100	0.21	1
	38-43	3	Rockland North Trestles	65	0.17	100	0.29	1
	38-43	2	Rockland North Trestles	6	0.08	76	0.01	
	40	3	Pier 39 EB	22	0.33	100	0.19	1
2017	26	2	Westchester Trestle and Falsework	64	0.08	76	0.10	1
Potential number of sturgeon affected								**6**

Estimate of the Number of Sturgeon that will Experience Physiological Effects

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, would likely 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 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 near the pile when pile driving begins to move away; thereby reducing the potential for exposure to noise levels that would be potentially fatal. 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 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; given the small number of piles remaining to be installed it is extremely unlikely that this will occur. Therefore, we do not expect any shortnose sturgeon or Atlantic sturgeon are likely to suffer major injury or die as a result of exposure to pile driving noise.

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 over 1,500 permanent piles in 2013, 2014 and 2015. Although dead sturgeon were observed, none of the necropsies indicate that the cause of death was barotrauma and exposure to pile driving noise is not suspected to be a cause of death for any of the dead sturgeon collected in the project area.

Pile driving will occur year round; therefore the Atlantic sturgeon exposed to pile driving noise are expected to be juveniles, subadults and adults. Based on the mixed-stock analysis, we expect that of the six Atlantic sturgeon that could experience physiological effects due to exposure to pile driving noise over the remainder of the project, five (92%) would be from the New York Bight DPS (juveniles, subadults or adults), and one would be from either the Gulf of Maine DPS (subadults or adults), or the Chesapeake Bay DPS (subadults or adults).

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 extremely unlikely. We do not expect any Atlantic sturgeon to suffer major injury or die as a result of exposure to pile driving noise.

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 596 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. 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; typically only Monday-Friday, with limited pile driving occurring on Saturdays. Over the course of the first five years of the project (2013-2017), 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. Pile driving is not anticipated in 2018. In the worst case, fish would avoid the ensonified 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, 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 six or fewer shortnose sturgeon and six or fewer Atlantic sturgeon over the remaining duration of the bridge replacement.

Through December 29, 2015, 1,500 piles had been installed (including trestle piles, test piles and production piles). Acoustic modeling was used to generate estimates of the number of sturgeon likely exposed to peak noise of 206 dB re 1uPa during the installation of these piles (see Table 8).

Given the number of piles remaining (see Table 8), we anticipate the exposure of six additional shortnose sturgeon and six additional Atlantic sturgeon to noise that may result in physiological impacts over the remaining duration of pile installation. We do not anticipate any serious injury or mortality.

7.2.5 Pile Removal at Coeyman's staging area

A total of 102 24"-diameter steel piles were installed to support finger trestles at the Coeymans staging area. After the final bridge assembly is transported from the Coeymans site, the trestles will be removed. A double walled silt curtain will be installed surrounding the trestles prior to demolition activities. A vibratory hammer will remove the piles. Noise associated with removing the piles is expected to be the same as during pile installation with the vibratory hammer. Therefore, increased underwater noise is not expected to extend beyond the silt curtain. Similarly, any increase in turbidity and suspended sediment will be contained within the silt curtain. No shortnose or Atlantic sturgeon will be exposed to any effects of pile removal due to the presence of the silt curtain.

7.3 Effects of Vessel Traffic

On September 11, 2015 FHWA requested reinitiation of formal consultation with us in response in part to increased concern regarding potential vessel strike effects for sturgeon in the Hudson River, and the realization that the use of fast-moving crew boats had not been considered in previous Opinions. Past Opinions only considered effects of tug boats travelling at less than six knots. FHWA submitted a final Biological Evaluation (BE) to us on January 6, 2016, and provided additional information through June 16, 2016. The purpose of the following analysis is to assess the potential for project vessels to strike and kill sturgeon in the vicinity of the project over the remaining three years of construction.

The factors relevant to determining the risk to Atlantic and shortnose sturgeon from vessel strikes are currently unknown, but based on what is known for other species we expect they are 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 sturgeon in the area (e.g., foraging, migrating, etc.). Geographic conditions (e.g. narrow channels, restrictions, etc.) may also be relevant risk factors. Large vessels have been typically implicated because of their deep draft relative to smaller vessels, which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Larger vessels also draw more water through their propellers given their large size and therefore may be more likely to entrain sturgeon in the vicinity. Miranda and Killgore (2013) estimated that the large towboats on the Mississippi River, which have a propeller diameter of 2.5 meters, a draft of up to nine feet, and travel at approximately the same speed as tugboats (less than ten knots), kill a large number of fish by drawing them into the propellers. They indicated that shovelnose sturgeon (*Scaphirhynchus platorynchus*), a small sturgeon (~50-85 cm in length) with a similar life history to shortnose sturgeon, were being killed at a rate of 0.02 individuals per kilometer traveled by the towboats. As the Mississippi and Hudson River systems differ significantly, and as shovelnose sturgeon densities in the Mississippi are not comparable to sturgeon populations in the Hudson, this estimate cannot directly be used for this analysis. We also can not modify the rate for this analysis because we do not know (a) the difference in traffic on the Mississippi and Hudson rivers; (b) the difference in density of shovelnose sturgeon and shortnose and/or Atlantic sturgeon; and, (c) if there are risk factors that increase or decrease the likelihood of strike in the Hudson. However, this information does suggest that large vessel traffic can be a major source of sturgeon mortality. In larger water bodies it is less likely that fish would be killed since they would have to be close to the propeller to be drawn in. In a relatively shallow or narrow area a big vessel with a deep draft and a large propeller would leave little space for a nearby fish to maneuver.

Although smaller vessels have a shallower draft and entrain less water, they often operate at higher speeds, which is expected to limit a sturgeon's opportunity to avoid being struck. There is evidence to suggest that small fast vessels with shallow draft are a source of vessel strike mortality on Atlantic and shortnose sturgeon. 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. In another case, a 35-foot recreational vessel travelling at 33 knots on the Hudson River was reported to have struck and killed a 5.5 foot Atlantic sturgeon (NYSDEC sturgeon mortality database (9-15-14)). Given these incidents, we conclude that interactions with vessels are not limited to large, deep draft vessels.

7.3.1 Project Vessel Operation

As described in Section 3, the construction of the new Tappan Zee Bridge involves the use of 156 vessels, 40 of which have propellers. Ten of these 40 vessels are work skiffs that are used intermittently as safety boats and tied up alongside barges or stored on barges when not in use. All of the project vessels operate primarily between Petersen's Marina, two miles upstream of the Bridge, and the Project's mooring field in the Regulated Navigation Area, which extends 1.25 miles downstream of the Bridge (Figure 3). These vessels maneuver within the navigational channel, as well as in the shallower areas in the Tappan Zee area. The non-propeller vessels are barges that are stationary except when being maneuvered into position by tugboats. There is only a risk of interacting with a sturgeon when the non-propeller vessels are being moved; these effects are considered where we consider operations of project tug boats. While the risk factors for interactions between vessels and sturgeon are unconfirmed, we anticipate that risk is greatest in conditions when the potential for avoidance is minimized. The potential for a sturgeon to avoid a vessel may be lowest when there is little clearance between the vessel and the river bottom and when vessels are moving at a high speed. The risk may be greater in areas where sturgeon are traveling up off the bottom, particularly if that behavior is occurring in areas where there is little clearance between the vessel and the river bottom as those factors in combination would increase the likelihood of exposure.

The navigational channel is maintained at depths of 30-45 feet from New York Harbor to Tappan Zee and depths of 32 feet between Tappan Zee and Coeymans. In addition to the channel, the vessels operate in the shallower areas around the bridge on the western side of the river in waters as shallow as seven feet deep, as well as in the access channel, which is 14 feet deep. Given the depth of water in these areas, the 17 crew boats and delivery boats, which have relatively shallow drafts (three to four feet), will occupy between 9% and 60% of the water depth, with a minimum of three feet between the vessel and the river bottom at all times. It is important to note that we do not know how much clearance is required to improve the ability of a sturgeon to avoid a vessel hull or propeller; however, we assume the smaller the portion of the water column occupied by the vessel, the more likely a sturgeon will be able to avoid the vessel.

Twelve project tug boats are currently in operation in the project area, with an additional contracted tug making two round trips a week between the project site and the Coeymans Staging Area. Of the thirteen tugs, eleven have a draft of three to six feet, one has a draft of nine feet, and one has a draft of thirteen feet. The vessel with the deepest draft is the tug that transports steel subassemblies between the bridge site and the Coeymans. While in the navigational channel, these vessels generally occupy less than a third of the water depth, however, in the much shallower 14-foot deep access channel they occupy a larger proportion of the water column. The majority of the tugs (11 of the 13) occupy less than half of the water depth, and maintain at least seven feet of depth between the tug and the river bottom. The deeper draft 9-foot project tug occupies 64% of the water depth in the 14-foot deep access channel (approximately five feet of clearance); however, this vessel rarely operates in the access channel (1.5% to 3.3% of the time based on AIS data from 2014-2015). The Coeymans tug never operates in the access channel, according to the same vessel data.

Based on activity between 2012 and 2015, FHWA reported in their BE that the project tugs have averaged 102 hours per day on the water. According to information provided by FHWA on February 19, 2016, tugs are anticipated to be active for 90,440 hours (2016: 30,440, 2017: 40,100, 2018: 19,900) over the remaining three years of construction. This yields an average of 30,147 hours per year, or 83 hours per day. This does not include activity associated with the tug that transits between the project location and the Coeymans staging area.

Instantaneous vessel speeds and locations were obtained from the U.S. Coast Guard’s Automatic Identification System (AIS) database and were examined for the five Project tugs included in the database (nearly 161,000 observations). During 2015 (January 1 through November 18), tugs spent 49% of the time (i.e., 50 of 102 hours) on station and not moving; during a typical work day, project tugs were in transit for 52 hours. While underway, tug boat speeds averaged 1.6 knots and were six knots or less 92% of the time. Project tugs only exceeded six knots 8% of the time, which is equivalent to 38 minutes per tug during an eight hour work shift. Tugs rarely exceeded speeds of eight knots (0.9% of the time or less than five minutes per tug during an eight hour work shift).

As indicated above, a contracted tug boat working for TZC transports steel girder assemblies from the Port of Coeymans to the construction site at the Tappan Zee Bridge (175 kilometers) twice weekly. Using AIS data from three downstream trips, the average speed of a typical contracted tug during transit between the Port of Coeymans and the Tappan Zee Bridge was determined to be 8.2 knots (range: 0.7 to 11.4 knots); the average speed through Haverstraw Bay to the Tappan Zee Bridge (from 19 measurements) was also 8.2 knots (range: 4.8 to 10.8 knots). The tug travels at speeds of six to eight knots during approximately 33% of the trip from Coeymans, and eight to ten knots during 58% of the trip, ten to eleven knots during 5% of the trip, and less than six knots during 4% of the trip.. During tows between Coeymans and the construction site, the tug operates within the federal navigation channel, where depths are between 30 and 40 feet, and adheres to United State Coast Guard Navigation Rules for International-Inland while in transit. FHWA submitted additional information to us on April 21, 2016, which indicates that 95 round trips still need to be completed between the project site and the staging area. Of these, 80 will occur between April 21, 2016 and November 30, 2016, while the remaining 15 trips will occur in 2017. At 24 hours per trip, it is anticipated that this tug will operate for 1,920 hours in 2016, and 360 in 2017.

There is minimal information available on the proportion of time at which crew boats and delivery boats travel within specific speed ranges. In FHWA's analysis, it is indicated that the 15 crew boats traveled between 15 and 25 knots (with a maximum speed of 35 knots) over a cumulative (2012-2015) 60,100 hours between May and September. TZC reported that both crew boats and delivery boats travelled a total of 116,400 hours since in water construction began in early 2013, and that they were active for 30,800 hours in 2015. On February 19, 2016, we received additional information from FHWA that indicates that the project crew boats are anticipated to be operational for 106,500 hours over the remaining three years of the project (2016: 42,300, 2017: 43, 600, 2018: 20,600). This yields an average of 35,500 hours per year.

One of the confounding variables in attempting to assess the impacts of project related vessel traffic on sturgeon is a lack of baseline data on vessel traffic in the action area. As noted in the Environmental Baseline, information on the number of commercial transits is available for 2009 – 2014; there is significant variability in the number of trips year to year. While there has been an increase in the number of deep draft vessels transiting to and from Albany during this time, there was not an overall increase in the amount of commercial transits. If deep draft vessels (>20 feet) pose an increased risk to sturgeon, this increase in deep-draft traffic, may have contributed to an increase in baseline risk of vessel strike since 2009.

NYSDEC Sturgeon Database

Since NYSDEC began maintaining records in 2007, there have been 139 dead sturgeon (mostly Atlantic sturgeon) recorded within the Hudson River. Of these, the majority (115 out of 139) were observed between 2013 and 2015, when vessel traffic associated with construction began on the new Tappan Zee Bridge (Table 9), and monitoring and reporting increased. The majority of sturgeon mortalities (76 of 115) since 2013 have been Atlantic sturgeon; 52 of which were assumed in the FHWA's BE to have been killed by vessel strike. Relatively few (23 of 115) of the mortalities reported since 2013 were shortnose sturgeon and very few (4) of those NYSDEC determined to be vessel related. Species was not determined for 16 of the reported carcasses. Of these, three were determined to be vessel-related mortalities. Since project vessel activity commenced in 2013, 24 (i.e. nineteen Atlantic sturgeon, four shortnose sturgeon, one unknown) of the 59 assumed vessel-related mortalities were reported from the project vessel impact area (defined as RM 12 to 34).

Monitoring Effort

With the exception of monitoring required by our Biological Opinions, the approach to monitoring for dead sturgeon in the Hudson River has been opportunistic, and has not involved a systematic strategy for surveying and recording occurrences. Prior to 2011, there was minimal awareness that vessel strike constituted a threat to sturgeon. According to the NYSDEC, record keeping became more intensive around 2011-2012 as a result of the recognition that Atlantic sturgeon on the Delaware River were being struck by large commercial vessels. From 2007-2011, the NYSDEC recorded four specific types of information when a sturgeon mortality was reported, i.e., date, observer contact, location of the sturgeon, and condition of the sturgeon. Sturgeon species was not specifically recorded, nor was the suspected cause of death. Beginning in 2012, a more comprehensive record keeping program was initiated by NYSDEC to document sturgeon mortalities in the Hudson River. At this point, they began recording approximately 12 specific types of information for each reported mortality, including sturgeon ID number, species, date, contact information, location, photodocumentation, body length, condition, disposition following the sighting, possible vessel strike, if the sturgeon was scanned for ID tags and painted, and other relevant comments.

As observations have been opportunistic, monitoring effort has not been consistent year to year or from place to place. It can be assumed that the listing of Atlantic sturgeon under the ESA in 2012 and the publicity associated with the construction of the new Tappan Zee Bridge led to increased public awareness of possible threats to the species. Additionally, Hudson Riverkeeper posted information on its website in 2012 and again in 2013 and the Thruway Authority distributed pamphlets and posted signage in 2014 to encourage public reporting. These public outreach efforts have likely contributed to the increased number of reports since in-water activities began in 2012. A focused monitoring effort by the NYSTA and TZC in the vicinity of the bridge also contributes to the number of sturgeon mortalities reported each year. Several of the conditions of the environmental permits for the Project, including our ITS, require that the NYSTA's environmental team and TZC to conduct mitigation measures on the river and monitor for dead and injured sturgeon during all dredging and impact pile driving activities. In addition, work crews are required to report any dead or injured sturgeon observed within the construction site at any time. The monitoring plan (TZC 2014) indicates that, in addition to onboard observers, transects would be conducted in the vicinity of the project, as well as one mile downriver, to document any injured or dead sturgeon during pile driving activity. As construction and environmental monitoring crews are on the river during the majority of the day on most days, the monitoring effort at the Tappan Zee Bridge is nearly continuous. The regular monitoring of the area by project staff is in sharp contrast to the sporadic observations reported by the public throughout the rest of the Hudson River. The disproportionate observation effort within the project area has increased the likelihood that sturgeon would be reported and, therefore, has potentially inflated the proportion of sturgeon mortalities in that area relative to the rest of the river. Since monitoring effort has been inconsistent it is difficult to compare reported mortalities in the Tappan Zee area to other parts of the river. The lack of comprehensive or consistent monitoring before the Tappan Zee project began also makes comparisons to pre-construction baseline not meaningful for drawing reliable conclusions. Of the 32 confirmed sturgeon mortalities reported between northern Haverstraw Bay and the George Washington (G.W.) Bridge, more than one-third (13 sturgeon) were reported to NYSDEC by the NYSTA and

TZC as a result of focused monitoring and during project-related mitigation activities in this area of the river.

The observations of dead sturgeon to-date have been invaluable in identifying vessel strike as a threat to listed shortnose and Atlantic sturgeon in the Hudson River. However, the inconsistent monitoring effort over time and river reach, makes it inappropriate to draw conclusions about the location and timing of the mortalities (i.e., when and where any individual was killed). As mentioned above, any sample of sturgeon mortalities in the River is not going to indicate the actual number of affected sturgeon, rather it will represent the minimum number killed, and without a standardized sampling effort it is not possible to develop a reliable estimate of the total number of dead sturgeon in the river, or to compare one river reach to another.

Table 9. A summary of the number of dead sturgeon observed in the Hudson River since vessel activity intensified on the Tappan Zee Bridge project in 2013. The impact area was defined in the analysis as the area between Croton Point (7 miles upriver of the project) and the G.W. Bridge (15 miles downriver of the project). This table is derived from Table 2 in the NYSTA Biological Evaluation.

	Total Mortalities	Assumed Vessel Mortalities	Reported Within Impact Area
Atlantic Sturgeon			
2013	17	10	4
2014	24	18	8
2015	35	24	7
2013-2015	**76**	**52**	**19**
Shortnose Sturgeon			
2013	6	1	1
2014	8	0	0
2015	9	3	3
2013-2015	**23**	**4**	**4**
Unidentified Sturgeon			
2013	2	0	0
2014	9	3	1
2015	5	0	0
2013-2015	**16**	**3**	**1**
Total	**115**	**59**	**24**

As indicated above, although the information derived from this database is useful for this analysis, it is only a sample of the sturgeon that died in the Hudson River over this time period and does not represent the total number because of the opportunistic nature of reporting and the likelihood that some sturgeon died but were not observed and reported. The NYSTA BE identifies several reasons why the database has limited utility in conducting an effects analysis (e.g. inconsistent monitoring and reporting prior to 2011, increased public awareness later in the time series that may have led to increased observation effort, oversampling in the project area compared to other areas). Additionally, the monitoring effort likely correlates spatially with human population density and boating activity, whereby the more populous areas in the lower river undergo higher levels of monitoring effort than the more sparsely populated areas upriver. We concur with NYSTA and FHWA's determination that these issues make it inappropriate to compare pre-2011 sturgeon observations with post-2011 determinations, but disagree that a "reasonable comparison among years may be made…because the level of monitoring and reporting was comparable among years…" (FHWA BE January 6, 2016). No information has been provided to us that indicates the level of monitoring effort from year to year. As FHWA points out, awareness of sturgeon mortalities in the river has gone up over time, and likely will continue to increase due to the publicity surrounding the Tappan Zee project. We cannot overemphasize the constraints on using data with inconsistent monitoring effort and a lack of standardized sampling (i.e. reach to reach, year to year) for the purposes of estimating the abundance of sturgeon at risk of being killed by project vessels in the future. For these reasons, the database should only be considered to represent the absolute minimum number of sturgeon that were killed in the Hudson River over the last nine years.

Source of Mortality

Ascertaining the cause of death for each of the fish within the NYSDEC sturgeon mortality database is critical to determining whether or not project vessels are contributing to vessel strike risk in the Hudson River. Only 4 of the 115 dead sturgeon observed between 2013 and 2015 were necropsied to determine cause of death. Most of the rest were observed and reported by the public on an opportunistic basis, along with photos and notes on signs of external injury. A small number of these were observed by NYSDEC or the Tappan Zee team but were not in good enough condition for a necropsy. Without necropsies, there is greater uncertainty as to whether or not the cause of death was vessel-related. The NYSDEC database and the BE analysis assumes that only fish that showed signs of propeller injury (e.g. propeller marks, missing head or tail) were killed by a vessel strike. There are no studies that we are aware of that supports this assumption, and it leads to potential bias in both directions. It is possible that some fish may have been killed by a vessel strike but did not exhibit external lacerations, such as the shortnose sturgeon that was discovered in the project area and was necropsied by Cornell University in August 2015. This fish had no lacerations but showed internal signs of blunt force trauma and "may have been struck by something blunt, such as the bow of a boat" (Cornell University Aquatic Animal Health Program, September 15, 2015). Conversely, other carcasses may exhibit external markings consistent with having been struck by a propeller (e.g. lacerations, missing appendages), but may have died from something else, and the strike occurred post-mortem. Therefore, the assumption that only carcasses with propeller marks were killed by vessel strike implies that no strikes occur post-mortem (i.e. any observed injuries are the cause of death), and that every vessel strike leads to obvious external injuries (i.e. no sturgeon dies of internal injuries that were not observable). These assumptions likely bias the analysis, and emphasize the need to treat the results of the analysis conservatively.

In the January 2016 BE, FHWA attempted to identify whether each of the vessel struck sturgeon was killed by a small vessel (i.e. project crew boats and delivery boats, recreational boats) or by a large vessel (i.e. tugs, other commercial vessels). They have made this determination based on the depth of the propeller injury, assuming that a propeller that can cut all the way through a fish must have been caused by the large propeller of a tug rather than by the smaller propeller of a recreational vessel or a crew boat. We are not aware of any studies that validate this assumption, although it has been used in other analyses (Brown and Murphy 2010, Rommel *et al.* 2007). If taking this approach, it would be critical to consider the size of the animal and where on the body the strike occurred. That is, it may take less force (smaller propeller size or spinning more slowly) to slice into or cut through the tail and more force (larger propeller or spinning more quickly) to slice through the body or decapitate an individual, with the force required different depending on the size of the animal (i.e., we would expect that a smaller propeller could slice through a small sturgeon, that same propeller may only damage a larger animal, in contrast, a larger propeller could decapitate both a small sturgeon and a large sturgeon). As with the above assumption, this leads to potential bias. If a propeller from a large vessel strikes, but does not completely sever the tail or head of a fish, the mortality would erroneously be attributed to a small vessel. Conversely, a small vessel could decapitate or de-tail a fish, depending on the propeller diameter and the angle/position of the strike on the body, and then the mortality would be incorrectly attributed to a large vessel. It is also possible that a fish struck by a small vessel could degrade to the point, after days or weeks of floating on the river, that a partially severed head or tail might become completely separated from the rest of the carcass. This fish could then be incorrectly classified as being killed by a large vessel. As described above, there is substantial uncertainty associated with attempting to determine whether or not a sturgeon was killed by a vessel strike or from some other cause. To attempt to ascertain the nature of the vessel that struck each individual fish could potentially compound this uncertainty. Although this method may correctly determine the vessel size for some proportion of the fish, we do not feel that its use is appropriate given the probability of mischaracterizing the size of the vessel. Therefore, for the purposes of our analysis, we have assumed that any vessel struck fish could have been killed by either a small or a large vessel.

Distribution of the Sturgeon Carcasses

The sturgeon carcasses observed on the Hudson since project related vessel traffic began in 2013 were distributed between New York Harbor and Stockport, NY, a distance of approximately 125 miles. The FHWA's BE indicates that 59 sturgeon carcasses observed between 2013 and 2015 were potentially killed by vessel strike (Table 9). While some of the sturgeon had clearly been killed recently, many showed signs of decomposition and had likely been floating in the river for days to weeks. Carcasses may be transported up and downriver multiple times prior to being observed and reported due to the strong tidal influence in the Hudson. Given the prevailing currents, over time a sturgeon struck by a vessel would be expected to drift in a net downstream direction.

In the BE, FHWA determines the distance a fish would be anticipated to float in the project area by using a drift analysis conducted by the NYSTA that used continuous current velocity data collected by NOAA's National Ocean Service (NOS) throughout the water column at the Tappan Zee and G.W. Bridges at 6-minute intervals during June 2005[19]. The use of this drift analysis assumes that the current in June 2005 is applicable to the conditions anticipated in the Hudson for the remainder of the project. Without information to the contrary, we assume that the current velocity data from June 2005 is a reasonable predictor of current velocity year-round. The drift analysis also assumes that all fish that are struck die instantly, rather than swimming elsewhere

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[19] To determine these distances, a drift analysis was conducted using continuous current velocity data collected throughout the water column at the Tappan Zee and George Washington Bridges at 6-minute intervals during June 2005 (http://tidesandcurrents.noaa.gov/cdata/StationList?type=Current+Data&filter=historic&pid=15).

to die after being injured by a vessel strike. While there could be some delay in death, available evidence indicates that vessel strike will cause injury that would significantly impede swimming ability; therefore, this assumption would not have a significant impact on the results. Using the FHWA analysis, it was concluded that if a vessel strike occurs at the northern extent of project vessel activity near Petersen's Marina on a low-rising tide and the sturgeon drifts upstream until the tide turns, it will not drift further than five miles upstream of Petersen's Marina (or seven miles upstream of the Tappan Zee Bridge). This analysis indicates that Croton Point Park, seven miles upstream of the project should be defined as the northern boundary of the vessel impact area because it is reasonable to expect a sturgeon struck within the project area would not drift upstream out of the area. A sturgeon killed by a vessel at the southern edge of the mooring field would be expected to drift a net distance of 15 miles downstream to the G.W. Bridge over a period of 48 hours. Over a 72-hour period, a sturgeon would drift approximately 26 miles from the Tappan Zee Bridge (river mile 27) to the Battery (river mile 0).

Although a sturgeon struck in the project area could drift downriver of the G.W. Bridge, the FHWA argues that the effect of the project on sturgeon would be masked by the high level of vessel traffic in that reach. That is, the area south of the G.W. Bridge has very high levels of vessel traffic, none of which are project vessels. If vessel traffic south of the G.W. Bridge were considered as part of the analysis of vessel impacts, project vessel traffic would represent an extremely small percentage of total traffic. If we assume that none of the sturgeon observed below the G.W. Bridge were killed by a project vessel, we could potentially underestimate the number of sturgeon struck in the vessel impact area. However, this may be partially offset by fish that are struck upriver of Croton Point that drift into the project vessel impact area, but it is impossible to quantify. Expanding the area of consideration downstream to RM 0 would mean considering all dead sturgeon observed in this reach and all vessel traffic in this reach; we expect this would result in an overall underestimate of the impact of project vessels on shortnose and Atlantic sturgeon and increased uncertainty in our estimate of the number of sturgeon likely to be struck over the remainder of the project.

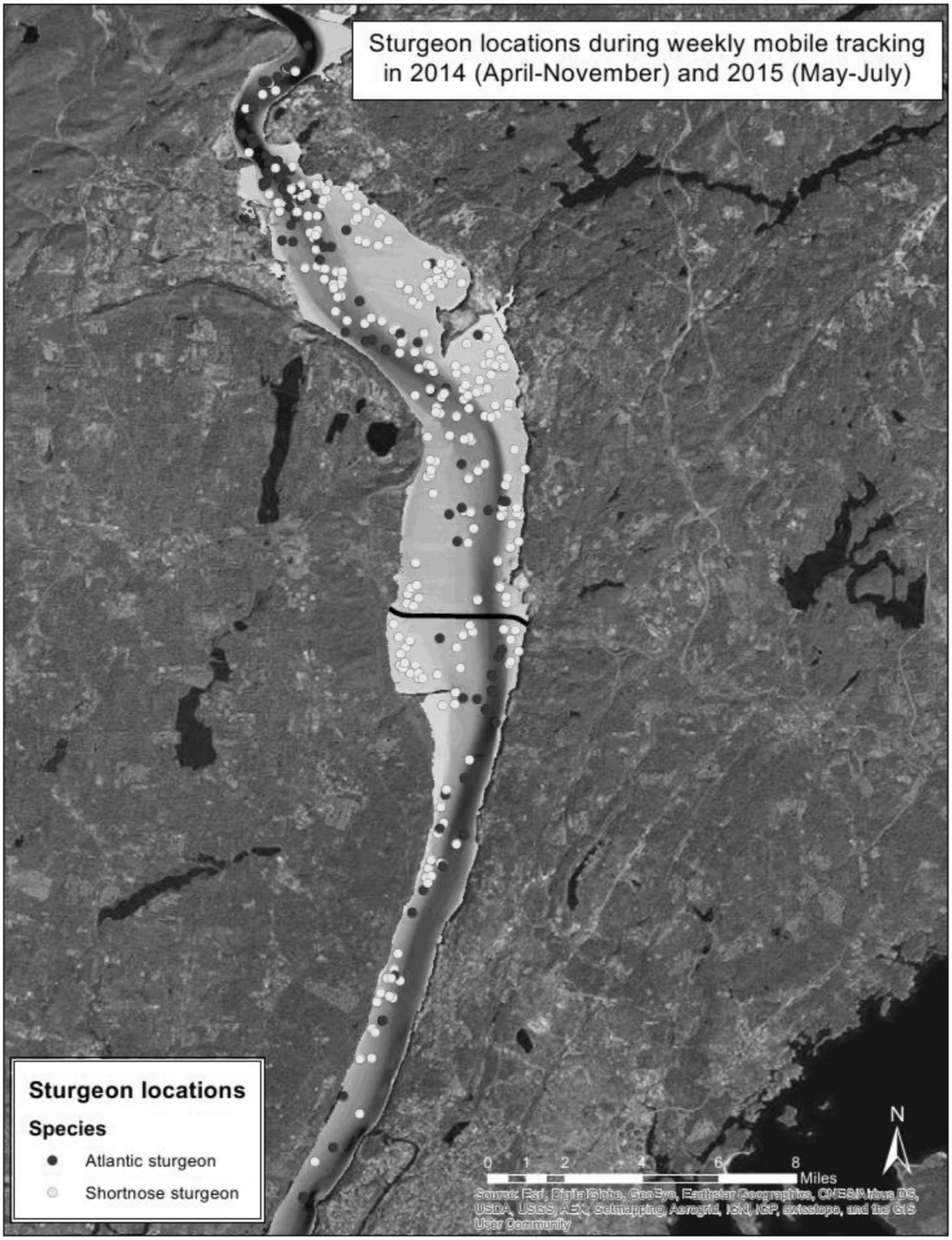
The FHWA BE limits the extent of the analysis of vessel impacts to the area between Croton Point and the G.W. Bridge (15 miles downriver of the project). We agree that it is reasonable to use this area when considering the effects of project vessels because: (1) this 22-mile vessel impact area encompasses the area of the river in which project vessel activity typically occurs (i.e., between Petersen's Marina, 2 miles upstream of the Bridge, and the Project's mooring field in the Regulated Navigation Area, which extends 1.25 miles downstream of the Bridge); and, (2) it encompasses the area where a sturgeon struck and killed in the area where project vessels transit would be expected to occur within 48 hours of its death (i.e., based on the drift analysis, it is not expected that a sturgeon would drift downstream out of this area within 48 hours).

In Table 3 of FHWA's BE, it is estimated that 24 of the 59 vessel struck sturgeon recorded in the NYSDEC database occurred within the 22-mile reach surrounding the Tappan Zee Bridge between 2013 and 2015, whereas 23 were struck in the 22-mile reach downriver (G.W. Bridge to NY Harbor), and 12 were struck upriver of Croton Point (approximately 62 miles). This analysis by FHWA assumes that sturgeon are killed instantly after being struck, since wounded fish could potentially swim into a different reach prior to dying, and that dead fish do not drift from one river reach into another. We believe it is reasonable to consider that sturgeon do not swim into a different reach after being struck as we expect vessel strike to result in injury that would significantly impair swimming ability. Dead fish will drift from one river reach into another over time; however, this is accounted for with the drift analysis. As the total number of sturgeon killed by vessel strikes in these reaches is unknown, and as the monitoring effort is uneven, few conclusions can be reasonably drawn from this analysis. However, it does indicate that vessel struck sturgeon (particularly Atlantic sturgeon) are being observed throughout the lower 100 miles of the Hudson River, both upriver and downriver of the project area.

As described previously, a telemetry study was conducted in the Hudson River during pile driving at the Tappan Zee Bridge site to monitor how sturgeon responded to acoustic effects associated with the project. Over the course of the study, 155 radio tagged Atlantic sturgeon were detected in the vicinity of the project, and their movements were monitored. The results of the study suggest that Atlantic sturgeon in the impact area are more likely to occur in the deepwater habitat in the main navigational channel than in shallower areas (Fig 5). Much of the project vessel activity occurs in the shallower habitat on the western side of the river, which is prohibited to non-project vessels. The FHWA BE indicates that while Atlantic sturgeon make up 95% of the reported sturgeon mortalities associated with vessel strike, 86% of Atlantic sturgeon detections were in water deeper than 6 meters. Given that Atlantic sturgeon spend the majority of their time outside of the shallower habitats where project vessels most often occur, the overlap between Atlantic sturgeon and project vessels is low. This reduces the exposure of Atlantic sturgeon to project vessels. Risk of vessel strike for Atlantic sturgeon may be higher in the navigational channel where there is more overlap between sturgeon and vessel activity. However, in addition to vessels associated with the project, the channel is used by hundreds of recreational and commercial vessels a week including large, deep draft vessels.

There is limited information on the effects of vessel operation on shortnose sturgeon. Only 5% of the sturgeon recorded in the NYSDEC database were identified as shortnose sturgeon. It is possible that this is because shortnose sturgeon are smaller and, therefore, not as susceptible to being struck by a vessel. Another possibility is that the species identification is incorrect in the database. Unless a sturgeon carcass is quite large, it is difficult to differentiate between the two species using a photograph. It is possible that some proportion of the sturgeon carcasses identified as Atlantics were actually shortnose sturgeon, although there is no evidence to suggest this is the case. However, if it is true, it would mean that the database underestimates the proportion of shortnose sturgeon that are struck by vessels in the Hudson River.

The NYSTA mobile-tracked shortnose sturgeon between Stony Point and the G.W. Bridge, and found that approximately 58% of all detections of shortnose sturgeon were in waters shallower than 6 meters (Fig 5). The telemetry study indicates that shortnose sturgeon use shallower habitats in the Hudson River in a much higher proportion than Atlantic sturgeon. This could indicate that they have a higher likelihood of being struck by project vessels in the shallower areas where construction activity is currently underway. Evidence indicates that shortnose sturgeon at least occasionally interact with vessels, as evidenced by wounds that appear to be caused by propellers. Although few confirmed vessel struck shortnose sturgeon carcasses (4) were observed in the Hudson River between 2013 and 2015, all of them were observed between the Tappan Zee Bridge and the G.W. Bridge (~15 mile reach). Three of the four necropsied carcasses detected in the vicinity of the project were shortnose sturgeon; but only two of these was considered by NYSTA and FHWA to have been a vessel strike mortality. NYSTA and FHWA determined that an additional carcass, necropsied on May 15, 2014, was not caused by a vessel strike, based on the necropsy determination that “the injury does not appear to be due to a ship strike or propeller impacts.” However, we note that the necropsy report indicated that Cornell could not “… completely rule out that the traumatic injury was caused by a ship strike” (Cornell University Aquatic Animal Health Program June 11, 2014) and that decapitation is consistent with injuries that Brown and Murphy (2010) ascribed to Atlantic sturgeon entrained through the propellers of large vessels. It is reasonable to take the conservative approach and conclude that this is a likely vessel strike. We note that all the shortnose sturgeon vessel strike observations occurred between the Tappan Zee and G.W. Bridges. As noted elsewhere in this Opinion, it is likely that the database underestimates the proportion of shortnose sturgeon being struck.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 5. Distribution of Atlantic and shortnose sturgeon based on mobile tracking data collected by the Thruway Authority during 2014 and 2015.

7.3.2 Project Vessel Strikes in the Hudson River

We have considered the likelihood that an increase in vessel traffic associated with the Tappan Zee Bridge replacement project added to the baseline vessel traffic would generally increase the risk of interactions between Atlantic sturgeon and shortnose sturgeon and vessels in the Hudson River. As explained above, there has been a significant localized increase in vessel traffic associated with the construction of the new bridge. Although the probability that any single project vessel would strike and kill a sturgeon is very small, the cumulative risk of all of the vessels on the river has been made apparent over the last few years due to increased monitoring and reporting on the river. The 40 project vessels with propellers will be operating for thousands of hours a year for the next three years. Despite their relatively small number, as explained below, these vessels make up a small, but not insignificant, proportion of the total vessel activity and, therefore, pose a corresponding risk to the Atlantic and shortnose sturgeon in the action area.

The vessel strike analysis within FHWA's BE focuses on the timeframe between 2012 and 2015 to determine what proportion of total vessel activity can be attributed to the project. However, as the intent of our analysis is to determine the project's likely effects on sturgeon in the action area in the future, we will consider the anticipated level of project-related vessel traffic between 2016 and November 2018, when the project is anticipated to be completed.

Large Vessels
The 13 project-related tugs, generally travel at slow speeds (less than six knots). The exception is the contract tug that delivers steel to the Coeymans staging area and bridge assemblies from Coeymans to the bridge site. This tug travels between six and ten knots. The only time that these vessels do not have at least 20 feet of navigational clearance between the bottom of the vessel and the river bottom is when they are maneuvering into position at Coeymans (i.e., the contract tug) or when operating outside of the access channel at the bridge site (i.e., the 12 project tugs). The majority of the tugs (11 of the 13) occupy less than half of the water depth, and maintain at least seven feet of depth between the tug and the river bottom. The deeper draft 9-foot project tug occupies 64% of the water depth in the access channel (maintaining five feet of depth between the tug and the river bottom in the access channel); however, this vessel rarely operates in the access channel (1.5% to 3.3% of the time based on AIS data from 2014-2015). The Coeymans tug never operates in the access channel, according to the same vessel data.

Based on vessel data from the U.S. Army Corps for 2014, approximately 15,799 non-Project commercial vessels, primarily tug boats and cargo ships, travel through the Tappan Zee area annually, which equates to 43 non-project commercial vessels per day. In order to determine the amount of time that non-project commercial vessels spend in the project area, FHWA estimated the amount of time it would take the vessels to transit between the G.W. Bridge (15 miles downriver of the Tappan Zee Bridge) and Stony Point (15 miles upriver of the Tappan Zee Bridge) given a constant speed. In our analysis, we have modified the study reach such that Croton Point (seven miles upriver) is the upriver limit, rather than Stony Point. FHWA indicated that the reason for using Stony Point is that a sturgeon observed and recorded in the NYSDEC database between 2012 and 2015 in the project area might actually have drifted into the area from where it was struck upriver of Croton Point. However, the intent of our analysis is not to account for sturgeon recorded in the NYSDEC database that were observed in the project area. Rather, the intent is to determine the proportion of vessels that can be attributed to the project, in order to determine the probability that the project will affect sturgeon over the remaining years of construction. The drift analysis indicates that if a vessel strike occurred at the northern extent of project vessel activity near Petersen’s Marina on a low-rising tide and the sturgeon drifted upstream until the tide turned, it would never drift further than five miles upstream of Petersen's Marina (i.e. Croton Point). Therefore, that is the appropriate upriver limit for this analysis.

Assuming a continuous speed of eight knots, which is typical based on AIS vessel data, a commercial vessel would transit the area within the navigation channel from the G.W. Bridge to Croton Point (22 miles) in 2.4 hours. Based on that, daily vessel traffic from non-project commercial vessels traversing the area within the navigation channel between the G.W. Bridge and Croton Point would be 103 hours per day, which is equivalent to 37,595 hours per year.

As described previously, project tugs are anticipated to operate for an average of 30,147 hours a year for the remaining years of construction, or 83 hours per day on average. However, the FHWA BE indicates that the tugs remained on station (no movement) for 49% of the time in 2015. Assuming this level of activity in the future, it is expected that project tugs will be active for 41 hours per day, which equates to 14,965 hours per year.

In operating hours, project tug boats represent 28% of all large-vessel traffic operating in the vessel impact area (14,965 hours ÷ (37,595 hours + 14,965 hours)). This is a substantially higher proportion than what was estimated by FHWA in their BE (i.e., 10 hours per day, or 3,650 hours per year in the navigation channel), as they limited their project activity estimates to hours when tugs were active within the navigation channel. As both Atlantic sturgeon and shortnose sturgeon occur within shallower areas (i.e. less than six meters) some proportion of the time (Atlantics 14% of the time; shortnose 58% of the time), and as project tugs spend the majority of their time (81%) in these areas, we do not feel it is appropriate to limit the analysis in this way. Project tugs may represent a small proportion of the overall large vessel traffic in the navigation channel, but represent a majority of the large vessel traffic outside of the channel. Therefore, we are using 14,965 hours to estimate incidental take for shortnose and Atlantic sturgeon, which is the amount of hours project tugs are expected to operate both within and outside the navigation channel. It is reasonable to use the operating hours within and outside the channel, because sturgeon are present in the channel and outside the channel and there is a risk of vessel strike in both areas. Using the approach considered in the BE is likely to underestimate the risk of strike by not considering the potential for strike outside of the navigation channel.

As the tug transporting steel sub-assemblies from the Port of Coeymans operates outside of the vessel impact area, we consider it separately from the other large vessels in our analysis. Based on the estimate of 43 non-project vessels per day between the Tappan Zee Bridge and the Coeymans staging area, there would be 301 one-way trips by non-project vessels per week, compared to five one-way trips per week for the project tug in 2016 (based on 80 round-trip transits between April 21, 2016 and November 30, 2016). Although we do not have information on when the 15 round-trip transits will occur in 2017, we will assume that it will occur at the same rate as in 2016 (i.e. approximately five one-way transits per week). Assuming that operating speeds are the same for all vessels during these trips (i.e., six to ten knots within the navigation channel), the transits made by the project tug going to and from Coeymans account for 1.6% of all vessel traffic operating between the Tappan Zee Bridge and Coeymans (i.e., 5 trips / 306 trips on a weekly basis). Even though there already is a high amount of vessel traffic in the action area, given the low probability of any single vessel would strike a sturgeon, adding this single tug boat's trips to the baseline along with other project vessels is not expected to increase the risk of a strike such that this tug would be likely to strike a sturgeon. We conclude it would still be extremely unlikely that this tug will strike a sturgeon.

Small Vessels

There is significant uncertainty in estimating the total amount of small vessel traffic in the vicinity of the project. We are not aware of a definitive estimate of vessel traffic within the Hudson River, and we anticipate that it fluctuates significantly. Recreational vessel traffic in the project area is seasonal with peak traffic occurring between the Memorial Day and Labor Day holidays and little or no recreational vessel traffic occurs between October and April (USCG 2012). Additionally, traffic likely varies significantly year to year, month to month, day to day, and hour to hour. To account for this variability, it is appropriate to describe the background level of boat traffic as a range, rather than as a discreet number. For our analysis, we will use one estimate proposed by the FHWA as a maximum estimate of annual vessel traffic over the remainder of the project, and another to represent the minimum number of vessels anticipated.

We assume that the estimate of vessel traffic presented in FHWA's BE is a maximum estimate of vessel traffic in the project area. It is based on a proportion of the total boat registrations in the three counties surrounding the project area. Statistics on recreational boats registered in Rockland, Westchester and Bergen Counties (NYSOPRHP 2014, HDR 2008) indicated a total of 26,724 recreational vessels are registered to owners at addresses within these three counties, of which approximately 22,593 are motorized vessels. To estimate the average number of vessel hours per week for motorized recreational vessels, FHWA estimated that the number of vessels was equivalent to 55% of all motorized recreational vessels in Westchester, Rockland and Bergen Counties. This estimate is based on the proportion of respondents to a 2012 Coast Guard Survey that had used their vessels in New York or New Jersey during the survey period (USCG 2012). FHWA assumed that the remaining 45% did not use their vessels. Vessel numbers in Westchester County were further adjusted to account for the fact that approximately one-third of motorized vessels use the Hudson River and the other two-thirds use Long Island Sound. In other words, FHWA's analysis assumes that 100% of boaters in Rockland and Bergen Counties, and 33% of the boaters from Westchester County, used their vessels in the Hudson River. This estimate assumes that: 1) boaters do not use their vessels on other waterbodies in New York and New Jersey, 2) all boats were used in the area of concern (i.e. the reach containing the Tappan Zee bridge), and 3) all boats were being used at any given time. Given these assumptions, we assume that this estimate represents the maximum number of boaters that could occur in the river reach containing the Tappan Zee Bridge. Based on this analysis, FHWA estimates that up to 8,300 small, recreational vessels are active in the project area.

A minimum estimate of small, recreational vessel traffic was derived by the FHWA in a supplement to the BE (submitted to us on February 2, 2016). To provide more information on the background levels of vessel traffic, they conducted an analysis of satellite imagery from October 2014 to estimate the number of motorboats that were at marinas on the Hudson River in

Westchester, Rockland, and Bergen counties. This analysis yielded an estimate of 3,100 vessels that were known to be on the river in the month of October in 2014. This estimate does not account for vessels that were used on the River, but were stored elsewhere. However, as the boating season is essentially at an end in October, it is reasonable to assume that the vessels observed made up the majority of vessels being used in the River at that time. Similar to the above estimate, this estimate assumes that these vessels are all being used in the impact area around the Tappan Zee Bridge, and that they are all being used concurrently. Despite this, this estimate represents the best available information regarding the minimum number of vessels active in this reach of the River during the boating season.

In order to estimate the level of vessel activity, it is necessary to estimate the amount of time that the vessels are active on the Hudson River. In their analysis, FHWA, citing US Coast Guard boating surveys from 2011 and 2012, indicates that the average number of recreational boat outings per year is 20 trips and the average duration per trip is five hours. This yields an estimate of 100 hours per year per vessel. Although this estimate is consistent with the average powerboat usage for boaters nationwide in 2011, it is higher than what was reported for the Northeast region that year, and higher than what was reported for the nation, region, or state in the 2012 report (Table 10).

Table 10. Estimates of average boating activity derived from survey data compiled by the US Coast Guard (USCG 2011, USCG 2012).

	2011		2012			
	Nationwide	Northeast	Nationwide	Northeast	NY	NJ
Days per Year						
All Boats	16.7	17.0	11.3	11.2	11.0	12.9
Powerboats	19.3	20.6	12.0	12.2	no data	no data
Hours per trip						
All Boats	4.5	3.7	5.7	5.3	4.9	6.4
Powerboats	5.1	4.3	6.0	5.8	no data	no data
Hours Per Year						
All Boats	75.2	62.9	64.4	59.4	53.9	82.6
Powerboats	98.4	88.6	72.0	70.8	no data	no data

Although the 2012 report provided information on state specific boat usage, it did not break it out by vessel type. As powerboats are the only type of vessel of concern in this analysis it is not appropriate to use data that represents all vessel types. We assume that the data presented in the 2011 and 2012 boating surveys for powerboats in the Northeast are the most relevant to this analysis. Therefore, we assume that non-project small vessels will spend an average of 70.8 to 88.6 hours per year per vessel in the project area.

Assuming that each vessel was active on the Hudson River for an average of 70.8 to 88.6 hours per year, we estimate that the total number of recreational vessel hours per year varies between 229,356 and 735,214 hours (Table 11). The range is indicative of the high level of uncertainty associated with this estimate; however, we consider this the best estimate of the vessel activity that is likely to occur within the project area over the next three years. In comparison, FHWA has estimated that project crew and delivery boats will be active for an average of 35,500 hours per year until November 2018. Therefore, we conclude that the crew and delivery boats represent a small proportion (5% to 13%) (i.e. 35,500 hours ÷ (35,500 hours + 229,356 (or 735,214) hours)) of all small-vessel traffic on the Hudson River in a given year. As this is the average proportion of project vessels year-round there are likely times when small project vessels represent significantly more than 13% of small vessels in the reach (e.g. midday on a rainy Tuesday) and times when they represent significantly less than 5% (e.g. sunny Saturday afternoon in the summer). Similarly, although the recreational boating hours are likely concentrated during the typical boating season (May to September), the project vessel activity is more evenly distributed throughout the year. Therefore, between May and September it is expected that project vessels will make up a smaller proportion of the total vessel traffic than in the winter, when non-project vessel activity is at its minimum.

Table 11. The estimated non-project small vessel traffic within the reach of the river containing the Tappan Zee Bridge project, based on the minimum and maximum estimates of vessel numbers and average time on the water.

Number of Non-Project Small Vessels	Average Hours Per Year	
	Minimum	Maximum
3,100	219,480	274,660
8,300	587,640	735,380

As we described previously, the analysis in FHWA’s BE separates out presumed vessel strike mortalities based on whether the strike occurred from a small vessel or a large vessel. We have concluded that this effort potentially compounds the error associated with using the NYSDEC sturgeon database for this analysis. Therefore, we have made the assumption that a sturgeon is just as likely to be struck by a small vessel, as by a large vessel. Large and small vessels may not pose an equal vessel strike risk to shortnose and Atlantic sturgeon; however, there is insufficient information to determine proportional risk. Small vessels may be easier for a sturgeon to avoid due to the vessels’ smaller size and shallower drafts. Similarly, their smaller propellers may not be strong enough to entrain larger sturgeon. They are harder to avoid, however, when they are going fast, and the greater speed increases the probability that a strike would lead to significant injury and death. Larger vessels may be easier to avoid due their slow speed, but their larger propellers entrain more water (and potentially fish). The effect of the large vessels is made worse by their deeper drafts, which limits the amount of space between the bottom of the river and the bottom of the vessel that is available for avoidance. Given these factors and because we can’t determine which causes a higher risk, we assume for the purposes of this analysis that the risk is equal.

Based on the assumption that small and large vessels pose an equal vessel strike risk to sturgeon, we have combined the operational hours from both types of vessels to establish the overall proportion of vessel traffic in the vessel impact area that is comprised of project vessels. Using the figures described above, we have estimated that project vessels, both large and small, make up 6% to 16% of the total vessel traffic in the impact area (i.e. (14,965 large project vessel hours + 35,500 small project vessel hours) ÷ (52,560 total large vessel hours + 254,980 (or 770,880) total small vessel hours)). Using the worst case year for sturgeon strikes in the vessel impact area in the NYSDEC database (ten sturgeon in 2015), we calculate that project vessels could kill 0.6 to 1.6 sturgeon annually. There are several reasons why we consider the higher end of this estimate to be reasonable (1.6 sturgeon annually, rounded up to 2). This is largely because it is based on calculations relying on the number of dead sturgeon reported to NYSDEC which we know is an underestimate of the total number of sturgeon killed in the river. While the high end of the estimate is based on the highest likely proportion of project vessels (i.e. 16%) there is significant uncertainty associated with estimating the number of non-project vessels present in the action area and we do not know the times of year or exact areas where risk is highest. While there may be times of year when project vessels consist of less than 16% of the vessels in the area, there are portions of the action area where non-project vessels are prohibited and project vessels are 100% of the vessels. Together these factors support our rationale to choose the most conservative calculated estimate.

Our estimate of two vessel strikes by project vessels per year considers both shortnose and Atlantic sturgeon. It is extremely difficult to determine the likely percentage of strikes that will be shortnose vs. Atlantic sturgeon because we do not have a complete understanding of the risk factors. For example, if we expected risk to be highest in the shallows, we would expect more shortnose sturgeon to be killed than Atlantics because shortnose are more likely to be found in the shallows. However, if risk is greatest in the navigation channel where there is more traffic generally, we would expect more Atlantic sturgeon to be killed. If fish size is a factor that could also make one species more likely that the other to be struck. Even if we assumed the risk of strike was equal for shortnose and Atlantic sturgeon, we do not know the proportion of Atlantic to shortnose sturgeon in the action area. While more Atlantic sturgeon than shortnose sturgeon have been detected on the acoustic receivers, there are thought to be more Atlantic sturgeon tagged in the river than shortnose, so that data can not be used to make predictions on the percentage of shortnose or Atlantic sturgeon in the area. Given this uncertainty, we anticipate that the sturgeon killed could be either shortnose sturgeon or Atlantic sturgeon.

We have made a number of assumptions (as identified above) in our analysis in light of the uncertainty surrounding a number of issues. Among the uncertainties we have addressed above are: the relative contribution of recreational vessels to total vessel traffic in the vessel impact area (which affects the percentage of total vessel traffic represented by the TZ project vessels; if our estimate of recreational traffic is too high, this would result in an underestimate of the relative contribution of project vessels, if our estimate is too low this would result in an overestimate of the relative contribution of project vessels); the cause of death of a number of the sturgeon recorded in the NYSDEC database (assuming that sturgeon that are decapitated or missing their tail were killed by vessels which could lead us to an overestimate; however, the assumption that sturgeon without major lacerations were not vessel strikes could lead us to an underestimate); the cause of death of the four sturgeon that were necropsied (concluding that three of the four sturgeon were killed by vessels, despite uncertainty in the conclusions of the experts, which could lead us to an overestimate); the actual number of sturgeon killed by vessels in the Hudson River as a whole or in the vessel impact area (assuming that the NYSDEC database represents a minimum count); assuming that all vessels are equally likely to strike a sturgeon and that the consequences of that strike would be the same (which could result in an underestimate or overestimate). We have used the best available information and made reasonable conservative assumptions to address uncertainty and produce an analysis that results in an estimate of the number of interactions between sturgeon and vessels that are reasonably certain to occur.

7.3.4 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 are affected by the high volume of commercial shipping traffic within the Hudson and New York Harbor. Martin and Popper (2016) recorded ambient noise levels in the Hudson River near the Tappan Zee Bridge. Recorded ambient noise levels, including recreational and commercial vessel traffic, did not exceed 140 dB SPLrms. These recordings are similar to results from other references of vessel noise recordings from other areas (Blackwell and Greene 2003, Richardson et al. 1995, Tetra Tech 2011). The Hudson River is subject to substantial commercial and recreational vessel noise under "normal" conditions, and any incremental increase of sound associated with vessel traffic related to bridge construction, when added to baseline conditions, is not expected to affect sturgeon as noise will remain under the 150 dB re 1uPa RMS threshold (above which sturgeon may react).

7.4 Effects of Using Concrete Cooling System

Tappan Zee Constructors (TZC) began testing and implementing a mass concrete pour once-through cooling system at the Pier 6 Westbound (P6WB) pile cap on November 20, 2014. Initial leak testing and flow adjustments were completed on November 20, 2014, and the concrete mass pour began and was completed on November 21, 2014.

Cooling system flows were adjusted to deliver approximately 5-6 gallons per minute (GPM) per cooling pipe or approximately 0.259 million gallons per day (MGD) to the system. Initial system testing confirmed flow was 5-6 GPM per cooling pipe throughout the system. Hourly concrete and cooling system intake and discharge temperature monitoring began on November 21, 2014 and continued until November 28, 2014.

TZC initiated similar system testing at P6EB beginning November 25, 2014 and at P7WB and P7EB on December 4, 2014 and December 5, 2014, respectively. Cooling system testing included modifications to the discharge configuration (multiple-point discharge vs. a single-point discharge) and temperature monitoring system (improved thermistor accuracy).

Over the 12 full days of system tests, the change in daily average temperature between the intake and discharge never exceeded 3°F. FHWA states this temperature difference is expected to remain the same regardless of the ambient temperature. In addition, no aquatic life was observed on or near the submersible pump screen or points of discharge.

Entrainment

Entrainment occurs when small aquatic life forms are carried into and through the cooling system during water withdrawals. Entrainment primarily affects small organisms with limited swimming ability that can pass through the wedge-wire screen mesh used on the intake systems. In order to be entrained in the cooling water intake, an organism would need to be able to pass through the 2mm mesh. No life stage of shortnose or Atlantic sturgeon is small enough to be vulnerable to entrainment (eggs are the smallest life stage and they are approx. 3mm diameter (Dadswell *et al.* 1984)). Because no shortnose or Atlantic sturgeon small enough to be vulnerable to entrainment occur in the action area, we do not expect any entrainment of shortnose or Atlantic sturgeon in the cooling water system.

Impingement

Generally speaking, impingement occurs when organisms are trapped against cooling water intake screens or racks by the force of moving water. Impingement can kill organisms immediately or contribute to death resulting from exhaustion, suffocation or injury. Below, we consider the potential for shortnose and Atlantic sturgeon to be impinged at the cooling water intake.

Background Information on Sturgeon Impingement Risk

Generally, impingement occurs when a fish cannot swim fast enough to escape the intake (e.g., the fish's swimming ability is overtaken by the velocity of water being sucked into the intake). A few studies have been carried out to examine the swimming ability of sturgeon and their vulnerability to impingement. Generally speaking, fish swimming ability, and therefore ability to avoid impingement and entrainment, are affected not just by the flow velocity into the intakes, but also fish size and age, water temperature, level of fatigue, ability to remain in a head-first orientation into current, and whether the fish is sick or injured.

In an experimental flume, Kynard *et al.* (2005) conducted tests of behavior, impingement, and entrainment of yearlings (minimum size tested 280mm FL, 324mm TL), juveniles (minimum size tested 516mm FL, 581mm TL) and adult shortnose sturgeon (minimum size tested 600mmFL, 700mm TL). Impingement and entrainment were tested in relation to a vertical bar rack with 2 inch clear spacing. The authors observed that after yearlings contacted the bar rack, they could control swimming at 1 and 2 feet/second (fps), but many could not control swimming at 3 fps velocity. After juveniles or adults contacted the rack, they were able to control swimming and move along the rack at all three velocities. During these tests, no adults or juveniles were impinged or entrained at any approach velocity. No yearlings were impinged at velocities of 1 fps, but 7.7-12.5% were impinged at 2 fps, and 33.3-40.0% were impinged at 3 fps. The range of entrainment of yearlings (measured as passage through the rack) during trials at 1, 2, and 3 fps approach velocities follow: 4.3-9.1% at 1 fps, 7.1-27.8% at 2 fps, and 66.7-80.0% at 3 fps. From this study, we can conclude that shortnose sturgeon that are yearlings and older (at least 280 mm FL) would have sufficient swimming ability to avoid impingement at an intake with velocities of 1 fps or less, as long as conditions are similar to those in the study (e.g., fish are healthy and no other environmental factors in the field, such as heat stress, pollution, and/or disease, operate to adversely affect their swimming ability).

- The swimming speed that causes juvenile shortnose sturgeon to experience fatigue was investigated by Deslauriers and Kieffer (2012). Juvenile shortnose sturgeon (19.5 cm average total length) were exposed to increasing current velocities in a flume to determine the velocity that caused fatigue. Fish were acclimated for 30 minutes to a current velocity of 5 cm/sec (0.16 fps). Current velocities in the flume then were increased by 5 cm/sec increments for 30 minutes per increment until fish exhibited fatigue. Fish were considered fatigued when they were impinged on the down-stream plastic screen for a period of 5 seconds (Deslauriers and Kieffer (2012).

- The current velocity that induced fatigue was reported as the critical swimming speed ("U_{crit}") under the assumption that the fish swam at the same speed as the current. The effect of water temperature on U_{crit} for juvenile shortnose sturgeon was determined by repeating the experiment at five water temperatures: 5°C, 10°C, 15°C, 20°C and 25°C. Shortnose sturgeon in this study swam at a maximum of 2.7 body lengths/second (BL/s) at velocities of 45 cm/s (1.47 fps). In this study, the authors developed a prediction equation to describe the relationship between Ucrit and water temperature. The authors report that amongst North American sturgeon species, only the pallid and shovelnose sturgeon have higher documented U_{crit} values (in BL/s) than shortnose sturgeon, this is true at any given temperature.

- Boysen and Hoover (2009) conducted swimming performance trials in a laboratory swim tunnel with hatchery-reared juvenile white sturgeon to evaluate entrainment risk in cutterhead dredges. The authors observed that 80% of individuals tested, regardless of size (80-100mm TL) were strongly rheotactic (i.e., they were oriented into the current), but that endurance was highly variable. Small juveniles (< 82 mm TL) had lower escape speeds (< 40 cm/s (1.31fps)) than medium (82–92 mm TL) and large (> 93 mm TL) fish (42–45 cm/s (1.47 fps)). The authors concluded that the probability of entrainment of juvenile white sturgeon could be minimized by maintaining dredge head flow fields at less than 45 cm/s (1.47 fps).

- Hoover *et al.* (2011) used a Blazka-type swim tunnel, to quantify positive rheotaxis (head-first orientation into flowing water), endurance (time to fatigue), and behavior (method of movement) of juvenile sturgeon in water velocities ranging from 10 to 90 cm/s (0.3-3.0 fps). The authors tested lake and pallid sturgeon from two different populations in the U.S. Rheotaxis, endurance, and behavioral data were used to calculate an index of entrainment risk, ranging from 0 (unlikely) to 1.00 (inevitable), which was applied to hydraulic models of dredge flow fields. The authors concluded that at distances from the draghead where velocity had decreased to 40cm/s (1.31 fps) entrainment was unlikely.

Risk of Impingement at the Concrete Cooling Intake

- Velocities through the intake screen will be 2.76 fps but due to the small amount of water being withdrawn and the low power of the pump, drop off rapidly as distance from the pump increases. Assuming worst case conditions (i.e., the highest anticipated withdrawal rate modeled at slack tide), FHWA reports velocities associated with this intake are expected to decline to about 0.5 fps within 1.2 inches of the intake screen and to about 0.1 fps within 6 inches of the screen.

- As established above, no sturgeon eggs or larvae occur in the action area. The youngest sturgeon would be juveniles. Boysen and Hoover (2009) reported the escape speed of small juveniles (<82 mm TL) to be 1.31 fps. Larger sturgeon are stronger swimmers and have faster escape speeds, meaning they can more readily avoid impingement. Even considering the smallest sturgeon that could be in the action area, a fish would need to be within 1 inch of the intake pump for there even to be a potential for impingement (at a distance of 1.2" velocity declines to 0.5 fps). Given the location of the pump in the upper water column where sturgeon only rarely occur, the very small surface area of the pump (less than 3 square feet), and the extremely small area where intake velocities could even be detected (at a distance of 6 feet, the velocity is 0.1 fps), it is extremely unlikely that a sturgeon would be impinged at the intake pump. The potential for impingement is further reduced by the existing tidal currents in the area which may make the velocity differential of the intake impossible for a sturgeon to detect. During field surveys conducted for the project, peak vertically averaged tidal currents in the navigational channel near the Tappan Zee Bridge were about 2.5 fps; peak velocities during the spring freshet were as high as 3 fps. Based on NOAA data on current velocities for the Tappan Zee area, the lowest current velocities between January and July 2012 ranged from 0.84 fps to 1.52 fps with daily maximum velocities ranging from 2.5 to 4.7 fps. This suggests that in most conditions, sturgeon are not likely to detect or orient to flows associated with the intake screen. Based on the analysis presented above, effects are discountable.

Thermal Discharge

Background Information on Thermal Tolerances of Sturgeon

Most organisms can acclimate (i.e. metabolically adjust) to temperatures above or below those to which they are normally subjected. Bull (1936) demonstrated, from a range of marine species, that fish could detect and respond to a temperature front of 0.03 to 0.07°C (0.05 – 0.13°F). Fish will therefore attempt to avoid stressful temperatures by actively seeking water at the preferred temperature.

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 27-30°C in the Connecticut River (Dadswell *et al.* 1984) and 34ºC in the Altamaha River, Georgia (93.2°F) (Heidt and Gilbert 1978). Foraging is known to occur at temperatures greater than 7°C (44.6°F) (Dadswell 1979). In the Altamaha River, temperatures of 28-30ºC (82.4-86°F) during summer months are correlated with movements to deep cool water refuges. Some information specific to the Hudson River is available. Smith (1985 in Gilbert 1989) reports that juvenile Atlantic sturgeon were most common in areas where water temperatures were 24.2-24.7°C. Haley (1999) conducted studies on the distribution of Atlantic and shortnose sturgeon in the Hudson River in 1995 and 1996. Water temperatures at capture locations were recorded. Atlantic sturgeon were found in warmer areas than shortnose sturgeon. The mean temperature of areas where Atlantic sturgeon were present was 25.6°C (s.d. +/- 2.0); the mean temperature for shortnose sturgeon was 24.34°C (s.d. +/- 2.8°C).

Ziegeweid *et al.* (2008a) conducted studies to determine critical and lethal thermal maxima for young-of-the-year (YOY) shortnose sturgeon acclimated to temperatures of 19.5 and 24.1°C (67.1 – 75.4°F). These studies were carried out in a lab with fish from the Warm Springs National Fish Hatchery (Warm Springs, Georgia). The fish held at this fish hatchery were reared from broodstock collected from the Altamaha and Ogeechee rivers in Georgia. Lethal thermal maxima were 34.8°C (±0.1) and 36.1°C (±0.1) (94.6°F and 97°F) for fish acclimated to 19.5 and 24.1°C (67.1°F and 75.4°F), respectively. The acclimation temperature of 24.1°C is similar to the temperature where shortnose and Atlantic sturgeon juveniles were most often found in the Hudson River (24.1°C) suggesting that this it is reasonable to rely on these results for assessing effects to Hudson River sturgeon. However, it is important to note that there may be physiological differences in sturgeon originating from different river systems. Fish originating from southern river systems may have different thermal tolerances than fish originating from northern river systems. However, the information presented in this study is currently the best available information on thermal maxima and critical temperatures for shortnose sturgeon. The study also used thermal maximum data to estimate upper limits of safe temperature, final thermal preferences, and optimum growth temperatures for YOY shortnose sturgeon. Visual observations suggest that fish exhibited similar behaviors with increasing temperature regardless of acclimation temperature. As temperatures increased, fish activity appeared to increase; approximately 5–6°C (9-11°F) prior to the lethal endpoint, fish began frantically swimming around the tank, presumably looking for an escape route. As fish began to lose equilibrium, their activity level decreased dramatically, and at about 0.3°C (0.54°F) before the lethal endpoint, most fish were completely incapacitated. Estimated upper limits of safe temperature (ULST) ranged from 28.7 to 31.1°C (83.7-88°F) and varied with acclimation temperature and measured endpoint. Upper limits of safe temperature (ULST) were determined by subtracting a safety factor of 5°C (9°F) from the lethal and critical thermal maxima data. Final thermal preference and thermal growth optima were nearly identical for fish at each acclimation temperature and ranged from 26.2 to 28.3°C (79.16-82.9°F). Critical thermal maxima (the point at which fish lost equilibrium) ranged from 33.7 (±0.3) to 36.1°C (±0.2) (92.7-97°F) and varied with acclimation temperature.

Ziegeweid *et al.* (2008b) used data from laboratory experiments to examine the individual and interactive effects of salinity, temperature, and fish weight on the survival of young-of-year shortnose sturgeon. Survival in freshwater declined as temperature increased, but temperature tolerance increased with body size. The authors conclude that temperatures above 29°C (84.2°F) substantially reduce the probability of survival for young-of-year shortnose sturgeon. However, previous studies indicate that juvenile sturgeons achieve optimum growth at temperatures close to their upper thermal survival limits (Mayfield and Cech 2004; Allen *et al.* 2006; Ziegeweid *et al.* 2008a), suggesting that shortnose sturgeon may seek out a narrow temperature window to maximize somatic growth without substantially increasing maintenance metabolism. Ziegeweid (2006) examined thermal tolerances of young of the year shortnose sturgeon in the lab. The lowest temperatures at which mortality occurred ranged from 30.1 – 31.5°C (86.2-88.7°F) depending on fish size and test conditions. For shortnose sturgeon, 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).

Limited information on the thermal tolerances of Atlantic 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 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). These tests were carried out with fish reared at the US Fish and Wildlife Service's Northeast Fishery Center (Lamar, PA) and are progeny of Hudson River broodstock. Thus, it is reasonable to rely on results of this study when considering thermal tolerances of Atlantic sturgeon in the Hudson River.

Tolerance to temperatures is thought to increase with age and body size (Ziegeweid *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. For purposes of considering effects of thermal tolerances, shortnose sturgeon are a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities.

Effect of Thermal Discharge on Shortnose and Atlantic Sturgeon

The lab studies discussed above indicate that thermal preferences and thermal growth optima for shortnose sturgeon range from 26.2 to 28.3°C (79.2-83°F). This is consistent with field observations which correlate movements of shortnose sturgeon to thermal refuges when river temperatures are greater than 28°C (82.4°F) in the Altamaha River. Lab studies (see above; Ziegeweid *et al.* 2008a and 2008b) indicate that thermal maxima for shortnose sturgeon are 33.7 (±0.3) – 36.1(±0.1) (92.7-97°F), depending on endpoint (loss of equilibrium or death) and acclimation temperature (19.5 or 24.1°C). Upper limits of safe temperature were calculated to be 28.7 – 31.1°C (83.7-88°F). At temperatures 5-6°C (9-11°F) less than the lethal maximum, shortnose sturgeon are expected to begin demonstrating avoidance behavior and attempt to escape from heated waters; this behavior would be expected when the upper limits of safe temperature are exceeded. For purposes of this consultation, we will consider these threshold temperature values to also apply to Atlantic sturgeon.

We first consider the potential for sturgeon to be exposed to temperatures which would most likely result in mortality. To be conservative, we considered mortality to be likely at temperatures that are expected to result in loss of equilibrium (33.7±0.3 for fish acclimated to temperatures of 19.5°C and 36.1±0.2 for fish acclimated to temperatures of 24.1°C). As noted above, shortnose and Atlantic sturgeon in the Hudson River are most often found in areas where temperatures are approximately 24°C suggesting that use of temperatures for fish acclimated to temperatures of 24.1°C is reasonable.

The maximum anticipated temperature of the thermal discharge is no more than 1.65°C above ambient. Ambient river temperatures in the Hudson River vary seasonally. Recorded extreme highs are 29°C[20] (August 2005). Assuming the historical record high will not be exceeded during the period the concrete cooling system is operational, water temperatures influenced by the thermal discharge will not exceed 30.65°C. Because 30.65°C is below the temperature that would result in a loss of equilibrium (and presumably, death), there is no potential for sturgeon to be exposed to lethal temperatures.

We have considered the potential for shortnose and Atlantic sturgeon to be exposed to water temperatures greater than 28°C (82.4°F). Available information from field observations (primarily in southern systems; however this may be related to the prevalence of temperatures greater than 28°C in those areas compared to the rarity of ambient temperatures greater than 28°C in northern rivers) and laboratory studies (using progeny of fish from southern and northern rivers) suggests that water temperatures of 28°C (82.4°F) or greater can be stressful for sturgeon and that shortnose and Atlantic sturgeon are likely to actively avoid areas with these temperatures. This temperature (28°C; (82.4°F)) is close to both the final thermal preference and thermal growth optimum temperatures that Ziegeweid *et al.* (2008) reported for juvenile

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[20] As reported at the USGS gage at West Point, NY (gage no. 01374019). Period of record dates from October 1991 – September 2014. Complete information available at: http://waterdata.usgs.gov/ny/nwis/uv?site_no=01374019.

shortnose sturgeon acclimated to 24.1 °C (75.4 °F). Thus, it is consistent with observations that optimum growth temperatures are often near the maximum temperatures fish can endure without experiencing physiological stress. Based on the available information, it is reasonable to anticipate that shortnose and Atlantic sturgeon will actively avoid areas with temperatures greater than 28°C.

From October – May, ambient river temperatures are not high enough such that the discharge could warm waters to 28°C (i.e., ambient water temperatures are below 26.35°C). In the summer months (June – September), ambient river temperatures can be high enough that temperature increases that will result from the discharge (up to 1.65°C) will be above 28°C. We expect sturgeon to avoid waters with temperatures above 28°C. CORMIX modeling reported by FHWA, developed using worst case conditions, indicates that at a distance of 56.7 feet away from the discharge, ambient temperature is increased by no more than 0.055°C. Bull (1936) demonstrated, from a range of marine species, that fish could detect and respond to a temperature front of 0.03 to 0.07°C. Therefore, it is reasonable to expect this represents the limit of potential behavioral response. That is, at horizontal distances beyond 56.7 feet from the discharge, water temperature increases would be so small that they would not be detectable by sturgeon. The thermal plume will exist at the surface (because warmer water is more buoyant than cooler water). The thermal plume will extend no deeper than 7.7 feet from the river surface (water depths in the area are at least 13 feet). Based on this information, it is reasonable to anticipate that on some days during the summer, sturgeon could encounter water temperatures resulting from the discharge and that they would avoid the plume. This potential for avoidance only exists when ambient water temperatures are above 26.35°C, which is limited to only a few days per year. A review of water temperature data for the last five years indicates that ambient temperatures above 26.35°C occur intermittently from mid-July to mid-August in most, but not all, years. Shortnose and Atlantic sturgeon exposure to the surface area where water temperature would be elevated above 28°C due to the influence of the thermal plume is limited by their normal behavior as benthic-oriented fish, which results in limited occurrence near the water surface. Assuming that there is a gradient of water temperatures that decreases with increasing distance from the outfall and decreases with depth from the surface, any surfacing shortnose or Atlantic sturgeon are likely to detect the increase in water temperature and swim away from near surface waters with temperatures greater than 28°C. Reactions to this elevated temperature are expected to consist of swimming away from heated surface waters by traveling deeper in the water column or by swimming around waters heated by the plume. The thermal plume is not anticipated to ever extend to the full depth of the water column.

Sturgeon in the action area are likely to be foraging, resting or migrating. Disruptions to these behaviors will be limited to moving away from the area with stressful temperatures. Given the small area that would have temperatures elevated above 28°C (extending no more than 56.7 feet from the discharge site, and not extending the full depth of the water column), any change in behavior would be limited to altering course to swim around or under the area with heated effluent. This extremely small alteration of normal movements would not result in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health. Effects of exposure to the thermal plume will be insignificant.

Effects to Prey

Shortnose and Atlantic sturgeon feed primarily on benthic invertebrates. These prey species are found on the bottom and are generally immobile or have limited mobility and are not within the water column. As explained above, increased water velocities, which could result in impingement or entrainment, will only be experienced within 1.2 inches of the intake screen. The intake screen will be located 2-3 feet below mean low water. Water depths in the area where the intakes will be located are at least 13 feet deep. Given the life history characteristics (sessile, benthic, not suspended in or otherwise occupying the water column) of shortnose and Atlantic sturgeon forage items and the location of the intake screen, it is extremely unlikely that there will be any loss of shortnose or Atlantic sturgeon prey. Therefore, the effect on shortnose and Atlantic sturgeon due to the potential loss of forage items caused by impingement or entrainment in the cooling water system is discountable.

As explained above, the thermal plume associated with the discharge from the cooling water system is a surface plume with no change in water temperature expected to occur at the river bottom. Given what is known about the plume (i.e., that it is a surface plume and will not impact water temperatures at or near the bottom) and the areas where shortnose sturgeon forage items are found (i.e., on the bottom), it is extremely unlikely that potential sturgeon forage items would be exposed to the thermal plume. Thus, based on this analysis, we do not anticipate any effects to the abundance, availability or accessibility of prey caused by the thermal discharge.

7.5 Effects of Increased Turbidity and Suspended Sediment

Certain activities will result in increases in turbidity and/or suspended sediment including 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.

There will 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.

7.6 Contaminant Exposure

Resuspension of sediments by 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, we believe 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 12. 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

7.7 Bridge Demolition

Bridge demolition will 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.

7.8 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.

7.8.1 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. The two spans of the new bridge would be separated by a gap up to 96 feet. 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. The height-to-width ratio for the portion of the existing bridge within the causeway is low, ranging from 0.25 to 0.34). The ratio for these same stations for the new bridge are generally much higher, ranging from 0.21 near the shoreline to 1.07. The portion of the western approach just prior to the main span has a ratio that ranges from 0.60 to 1.11 for the existing bridge. Again, the ratios of these stations for the new bridge are much greater, ranging from 1.07 to 1.47. The ratio for the main span of the existing bridge is 1.57 and for the replacement bridge 1.39 to 1.67, while the ratios for the eastern approach are fairly similar for the existing and new bridge, ranging from 0.89 to 1.43.

The separation between the decks of the two spans (i.e., 96 feet at the main span and then decreasing toward the shorelines) 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.

7.8.2 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 (RMs 24-33). 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. The platform will be located approximately 1.5 miles from the 20-foot depth contour and the edge of the navigation channel. 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.

7.8.3 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.

7.8.4 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.

7.9 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.

7.9.1 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.

Tagging and Tracking and Gastric Lavage

The mitigation plan required the capture and tagging of sixty shortnose sturgeon and sixty Atlantic sturgeon. Fish were to be tagged with LOTEK Dual Mode sonic transmitters. Tracking of acoustically tagged fish will then be undertaken with both mobile and stationary receivers. 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). 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. In July 2014, NYSDEC's existing Section 10 permits (#16439 and #16436, see discussion in section 6.1 above) were modified to authorize this sampling. The appropriate section 7 consultation determinations were made regarding the modification of these two research permits.

Sampling for tagging and lavage of sturgeon occurred between April 16 and September 19, 2014, and June 10 and July 10, 2015. Sixty Atlantic sturgeon were tagged (30 in the 450-1000mm size range and 30 sized 1000 to 1300 mm). Fifty-five shortnose sturgeon were tagged (33 larger than 500 mm and 22 sized 300 – 500 mm). A total of 210 sturgeon were either tagged or lavaged over 57.5 days of effort. All fish collected were released alive back into the river with the exception of one young of year shortnose sturgeon that was retrieved dead from the trawl (cause of death considered to be crushing by large debris in the net).

Outreach Efforts

An outreach campaign was implemented in the summer of 2014 that consisted of designing and distributing signs and pamphlets to beach managers at several parks and a marina along the south shore of Long Island. An additional 70 signs and 1,500 pamphlets were provided to NYSDEC for further distribution. No effects to Atlantic or shortnose sturgeon are anticipated to result from the development or implementation of the outreach efforts.

7.9.2 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. Current investigations undertaken by NYSTA in the project vicinity are focusing on understanding seasonal timing of oyster spat settling, and the relative efficacy of reef balls and gabion structures for oyster recruitment and growth. 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

Gay's Point is located over 90 miles upstream of the Tappan Zee bridge. 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 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. Except for conceptual drawings for two green infrastructure projects intended to manage stormwater discharging into Sparkill Creek, there are currently no other conceptual or construction plans for other aspects of this wetland enhancement mitigation. 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 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 –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 that was carried out during the bridge replacement project was expected to result in the capture of no more than one shortnose sturgeon and one Atlantic sturgeon. No capture, injury or mortality of sturgeon occurred during the dredging. In previous Opinions we estimated that pile driving would result in the minor injury of up to 37 shortnose sturgeon and 37 Atlantic sturgeon and that one of these shortnose sturgeon and one of these Atlantic sturgeon would experience major injury or be killed. However, in-field monitoring of pile driving conducted through December 29, 2015 indicates that the completed pile driving resulted in the minor injury of no more than eight shortnose sturgeon and eight Atlantic sturgeon (seven NYB DPS and one Chesapeake Bay or Gulf of Maine DPS). No sturgeon with major injuries or dead sturgeon were observed where there was any evidence of barotrauma. Therefore, we conclude that no sturgeon have suffered major injury or death as a result of exposure to pile driving noise. We do not have any information that effects due to bed leveling, armoring the river bottom, turbidity, any release of contaminants, loss of prey, and NYSDEC-required mitigation activities to date were anything but insignificant or discountable as anticipated in our last Biological Opinion. We do not know whether any project vessels struck sturgeon to date and, if they did, what the fish’s (or fishes’) fate was. In 2016 and 2017, impact pile driving is expected to result in the minor injury of up to six additional shortnose sturgeon and six additional Atlantic sturgeon. 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.

Normal sturgeon behavior is expected to result in avoidance of areas loud enough to cause significant injury or mortality. As explained in Section 7 above, we do not anticipate the serious injury or mortality due to exposure to pile driving noise of any shortnose or Atlantic sturgeon.

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, potential exposure to contaminants, and effects to prey items. We have determined that all behavioral effects will be insignificant and discountable. We also determined that effects of exposure to contaminants and effects due to impacts to prey will be insignificant and discountable.

For the reasons explained in Section 7 above, we anticipate that sturgeon will be struck by project vessels (both tugboats and smaller vessels) over the remaining years of the project (2016-2018). We have estimated that up to two sturgeon a year are likely to be struck by project vessels, for a total of six. These mortalities could be either Atlantic or shortnose sturgeon. Given that the majority of Atlantic sturgeon in the action area originate from the New York Bight DPS, the Atlantic sturgeon that are likely to be seriously injured or killed by vessel strike are likely to be from the New York Bight DPS; however, given the presence of Atlantic sturgeon from the

Gulf of Maine and Chesapeake Bay DPSs in the action area, it is also reasonable to expect that a sturgeon struck by a project vessel could originate from the Gulf of Maine or Chesapeake Bay DPS. Because we cannot predict the percentage of interactions that will be with shortnose or Atlantic sturgeon, we are analyzing the effects of the death of six shortnose sturgeon and six Atlantic sturgeon over the next 3 years in order to be conservative for each species in this jeopardy analysis. Our jeopardy analysis would not change even if we were to assume there were project vessel strikes in the past 3 years and they were at the same level as we estimate for the next 3 years.

In the discussion below, we consider whether the effects of the action as a whole (i.e., past and future effects) 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 action, in the context established by the status of the species, environmental baseline, and cumulative effects, is likely to 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 action, we summarize the status of the species and consider whether the 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 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 four 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 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 populations 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, adds uncertainty to any determination on the status of this species as a whole. Based on the best available information, however, the status of shortnose sturgeon throughout their range is stable (SSSRT 2010).

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 we obtain 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. For example, one mortality in research sampling was reported in 2014. We have no reports of interactions or mortalities of shortnose sturgeon in the Hudson River resulting from dredging or other in-water construction activities. We have 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. There is 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 us. Since reporting requirements were implemented in 2000, less than the exempted number of takes (six 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. As explained in the Environmental Baseline section, a number of dead sturgeon in the Hudson River are reported to NYSDEC. This number has been growing since data collection began, but effort and interest have also increased which makes it impossible to determine if there has been an actual increase in sturgeon mortalities in the river. Similarly, while at least some of these dead sturgeon appear to have been struck by vessels, we do not know if that number has increased over time or, in some cases, whether the strike occurred post-mortem. 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. We are concerned about the potential impacts of an increase in the number of large deep draft vessels transporting oil from Albany and any associated increase in risk of vessel strike; however, we do not have enough information to understand how much this increases risk or how that increased risk would translate to an increase in sturgeon mortalities21. 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, we expect that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the action.

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[21] See for example, "Bakken Crude, Rolling Through Albany" New York Times Feb. 27, 2014 and Hudson Riverkeeper "Crude Oil Transport" (http://www.riverkeeper.org/campaigns/river-ecology/crude-oil-transport/)

Pile driving to date has resulted in the exposure of eight shortnose sturgeon to noise that we expect resulted in physiological impacts amounting to minor injury. Considering piles that remain to be installed in 2016 and 2017, we anticipate the minor injury of six shortnose sturgeon during the remaining installation of piles with an impact hammer. 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; (5) 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, (6) 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 remaining activities associated with the bridge replacement project (up to six from vessel strike), 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 six shortnose sturgeon over the remaining three years of construction will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the 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 0.014%).

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 six shortnose sturgeon over the remaining three years of construction would affect the overall 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 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 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 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 action is less than 0.014% 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 on the effects of the action, including the death of up to six shortnose sturgeon between 2016 and the end of 2018, , the Tappan Zee Bridge replacement project 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 six shortnose sturgeon 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; (6) 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 (7) 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, we have determined that the 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 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 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 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 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 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 action as a whole (i.e., past and future effects when added to baseline conditions) is not likely to appreciably reduce the survival and recovery of this species.

9.2 Atlantic sturgeon

Pile driving to date has resulted in the exposure of eight Atlantic sturgeon to noise that we expect resulted in physiological impacts amounting to minor injury. Based on the amount of pile driving remaining, we expect six additional injuries to occur in 2016 and 2017 before pile installation is complete. 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 in the Effects of the Action section, 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 six injured fish, five will originate from the NYB DPS, and one from either the GOM DPS or the CB DPS. We expect up to six sturgeon will be killed due to interactions with project vessels and, taking a conservative approach to this analysis, we will consider the effect on survival and recovery assuming all six are Atlantic sturgeon. These fish 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 remaining activities associated with the bridge replacement project will result in the injury due to exposure to pile driving noise of six or fewer Atlantic sturgeon, of which one is likely to be from the GOM DPS. The following analysis applies to anticipated effects of injury of one individual, 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 six injured fish being from the GOM DPS. Sturgeon that experience minor injuries are expected to fully recover. These injuries will not 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 six Atlantic sturgeon due to interactions with project vessels,with no more than one likely to originate from the GOM DPS. Given the very low number of adult GOM DPS Atlantic sturgeon likely to occur in the action area, it is extremely unlikely that this one fish will be an adult. All other GOM DPS Atlantic sturgeon in the action area are subadults, therefore we anticipate that if a GOM DPS Atlantic sturgeon interacts with a project vessel it will be a subadult. Here we consider the effects to the GOM DPS from the loss of one subadult (>760mm TL <1,500 mm TL). 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 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 action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by GOM DPS fish.

Because the action 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 a very small percentage of the population.

The 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, including the death of up to 1 GOM DPS Atlantic sturgeon between now and the end of 2018, the action 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 2018 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 action 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 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 action will appreciably reduce the likelihood that the GOM DPS can rebuild to a point where it is no longer in danger of extinction throughout all or a significant part of its range.

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 action will affect the likelihood of recovery of the GOM DPS.

This action will not change the status or trend of the GOM DPS. The action will result in a small amount of mortality (one subadult over three 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 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 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, it 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 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. Atlantic sturgeon occur in several rivers in the NYB DPS; spawning occurs in the Delaware and Hudson rivers. The capture of age 0 Atlantic sturgeon in the Connecticut River in 2014 indicates that spawning occurs at least occasionally in this river. Preliminary genetic analysis indicates that the Atlantic sturgeon in the Connecticut River are genetically distinct from Atlantic sturgeon spawned in the Delaware and Hudson rivers. All juveniles in the action area will be Hudson River origin because juveniles do not migrate from their natal river. New York Bight DPS origin subadults and adults could originate from the Hudson, Delaware or Connecticut River. However, given the location of the project in the Hudson River and the overwhelming proportion of Hudson River origin Atlantic sturgeon in the river compared to Delaware River and our determination that Connecticut River fish would make up an even smaller proportion, we expect that any interactions with New York Bight DPS Atlantic sturgeon would be Hudson River origin.

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.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 that 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. The closure of the commercial fishery coastwide in 1997 should have led to an increase in the number of adults in the population which should result in increased recruitment. While there is no trend data available for subadults and adults, there is an overall positive trend for juveniles of the size class vulnerable to capture in the FJS.

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 remaining pile driving will result in the minor injury of six or fewer Atlantic sturgeon due to exposure to pile driving noise; we expect five of these sturgeon will be from the NYB DPS. The following analysis applies to anticipated effects of injury of five 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 six injured fish are from the NYB DPS. Sturgeon experiencing minor injuries are expected to fully recover. These injuries will not 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 anticipate the mortality of six Atlantic sturgeon due to interactions with project vessels, with five likely to originate from the New York Bight DPS. We expect that these mortalities will be juveniles (<500 mm TL), subadults (<1,500 mm TL) or adults. As explained above, we expect the individuals to originate from the Hudson River but it is possible that an individual could originate from the Delaware River. The best available information indicates that the number of Connecticut River origin Atlantic sturgeon is extremely low; therefore, it is extremely unlikely that any of the six sturgeon killed will have originated from the Connecticut 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 six Atlantic sturgeon from the NYB DPS between now and the end of 2018 represents a very small percentage of the population. While the death of up to six Atlantic sturgeon will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the action, this reduction in numbers will not change the status of this species as this loss represents a very small 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 six female juveniles, subadults or adults over a three year period 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 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 six male juveniles, subadults or adults 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 the Connecticut, 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..

The action is not likely to reduce distribution because it 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, including the death of up to six NYB DPS Atlantic sturgeon between now and the end of 2018, the replacement of the 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 will not have an effect on the levels of genetic heterogeneity in the population; (4) the loss of six Atlantic sturgeon 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 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 action will appreciably reduce the likelihood that Atlantic sturgeon can rebuild to a point where the NYB DPS of Atlantic sturgeon is no longer in danger of extinction throughout all or a significant part of its range.

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 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 action will result in a small amount of mortality (no more than six individuals over three 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 stable trend of the population. The 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 disturbing levels of noise) is small. The 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 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 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 remaining activities associated with the bridge replacement project will result in the injury due to exposure to pile driving noise of six or fewer Atlantic sturgeon , of which no more than one will originate from the Chesapeake Bay DPS. The following analysis applies to anticipated effects of 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 six injured fish being from the CB DPS. Sturgeon that experience minor injuries are expected to fully recover. These injuries will not 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 six Atlantic sturgeon due to interactions with project vessels with no more than one likely to originate from the Chesapeake Bay DPS. Given the very low number of adult Chesapeake Bay DPS Atlantic sturgeon likely to occur in the action area, it is extremely unlikely that this one fish will be an adult. All other Chesapeake Bay DPS Atlantic sturgeon in the action area are subadults. Therefore, we anticipate that if a Chesapeake Bay DPS Atlantic sturgeon is struck, it will be a subadult. We, therefore, 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 individuals that would be killed as a result of the 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 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. 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 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 the action will result in the loss of only one individual, we do not expect this to change the status or trend of the Chesapeake Bay DPS as the loss is thought to represent a very small percentage of the population.

The action is not likely to reduce distribution because the action 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 action is 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, including the death of up to one CB DPS Atlantic sturgeon between now and the end of 2018, the Tappan Zee Bridge replacement project 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 will not 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 2018 will not 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 action 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 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 throughout all or a significant part of its range.

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 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 action will result in a small amount of mortality (1 subadult over three 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 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 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 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 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 action as a whole including interrelated and interdependent activities, and the cumulative effects, it is NMFS' biological opinion that the replacement of the Tappan Zee Bridge is likely to adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of

Atlantic sturgeon. No critical habitat is designated in the action area; therefore, none will be affected by the action.

11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. “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. 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.

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 as of the date of the Biological Opinion. This Biological Opinion is a result of the reinitiation of a consultation that concluded with the issuance of an Opinion on September 24, 2014. Our previous Opinions on the effects of the Tappan Zee replacement project have exempted take resulting from dredging (none was observed) and pile driving. Those Opinions included ITSs exempting the take of shortnose sturgeon and five DPSs of Atlantic sturgeon. Pile driving completed to date has likely resulted in the injury of eight shortnose sturgeon and eight Atlantic sturgeon. This past take of those sturgeon was exempted by the ITS accompanying the previous Opinions.

11.1 Amount or Extent of Take

Remaining pile driving to be carried out for construction of the new bridge is expected to result in the injury of six or fewer shortnose sturgeon and six or fewer Atlantic sturgeon (five New York Bight DPS and one Chesapeake Bay DPS or one Gulf of Maine DPS). All of these fish are expected to suffer minor injuries and no serious injury or mortality is anticipated. As explained in the “Effects of the Action” section of the Opinion, none of these sturgeon are expected to die, immediately or later, as a result of exposure to increased underwater noise levels resulting from pile driving. All injuries are anticipated to be minor and any injured individuals are expected to make a full recovery with no impact to future survival or fitness.

We expect that up to six sturgeon (combination of shortnose and Atlantic sturgeon; New York Bight DPS and no more than one from Chesapeake Bay DPS or Gulf of Maine DPS) will be struck and killed by a project vessel over the remaining years of the project (2016 to 2018).

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 increased turbidity and to contaminants, effects to prey items, the existing bridge's demolition, operation of the new bridge, and effects of mitigation activities required by the NYSDEC. We have determined that all such aspects of the action will have no effect or will have insignificant and discountable effects on sturgeon. We do not anticipate any take of shortnose or Atlantic sturgeon resulting from any remaining aspect of the project, except from pile driving and project vessel strikes.

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

Type of Take	**Shortnose Sturgeon**	**Atlantic Sturgeon**
Injury (due to exposure to pile driving noise)	6 (juvenile or adult)	6 total 5 NYB DPS (juvenile, subadult or adult) 1 GOM DPS (subadult or adult) OR1 CB DPS (subadult or adult)
Mortality (Vessel Strike)	6 (juvenile or adult)*	6 total* 5 NYB DPS (juvenile, subadult or adult) 1 GOM DPS (subadult or adult) OR 1 CB DPS (subadult or adult)

*we expect a total of six sturgeon to be killed by vessel strike – these will be a combination of shortnose and Atlantic sturgeon

In the accompanying Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to shortnose sturgeon or to any DPS of Atlantic sturgeon.

While we have been able to estimate the likely number of shortnose and Atlantic sturgeon to be taken as a result of the 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 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 the observers will be able to detect any dead, dying or stunned sturgeon present at the water surface. We do not expect the observer to be able to detect fish that remain underwater or only experience minor injuries and quickly swim away from the project area.

Noise

We considered several methods to monitor the validity of our estimates that there will be six or fewer shortnose, and six 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 ensonified 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, which trawling or gillnetting them might do. 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 all of the monitoring methods considered above are neither reasonable and prudent nor necessary or appropriate , we will use a means other than counting individuals to monitor the estimated numerical level of take and provide a means for reinitiating consultation once that level has been exceeded. For this action, the spatial and temporal extent of the area where underwater noise levels will be greater than 206 dB re 1uPa peak due to the remaining pile driving provides a proxy for monitoring the actual amount of incidental take. We expect that this proxy will be the primary method of determining whether incidental take has been exceeded, given the potential that stunned or injured fish will not be observed. However, in order to increase the chances of detecting when incidental take has been exceeded, we have identified other, complementary monitoring 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, it is unlikely that we have underestimated take.

We will consider incidental take exceeded if any of the following conditions are met:

i) More than six stunned or injured shortnose sturgeon are observed within one mile down-current of the pile driving (based on peak current velocities at the time of pile installation).

ii) More than five stunned or injured New York Bight DPS and one stunned or injured Chesapeake Bay DPS or one Gulf of Maine DPS Atlantic sturgeon are observed within one mile down-current of the pile driving (based on peak current velocities at the time of pile installation)

iii) Any dead shortnose sturgeon or dead Atlantic sturgeon (belonging to the NYB, CB or GOM DPS) are observed within one mile down-current of the pile driving (based on peak current velocities at the time of pile installation) with injuries that are attributable to pile driving (e.g., evidence of barotrauma).

Additionally, we will consider that the numerical estimate of incidental take from the remaining pile driving was exceeded if, based on Table 8, either:

(a) The width of the 206 dB re 1 µPa peak isopleth is greater than 100 ft. for 3 ft. piles, or 76 ft. for 2 ft. piles, which is related to the area used to calculate the number of takes anticipated, **or**

(b) The amount of time to drive a pile exceeds the figures listed in Table 8 for 2016 and 2017, which are related to the number of anticipated takes and the severity of the take, **or**

(c) More total piles or more piles of any size are installed than listed in Table 8.

Assignment of any fish collected to one of the DPSs would depend on the ability to obtain a fin clip for genetic testing. 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.

Vessel Strikes

We have been able to estimate the likely number of shortnose and Atlantic sturgeon that will be struck by project vessels; however, detection of strikes may be difficult. There is one report in the NYSDEC database that suggests that the operator of a recreational vessel realized they hit something and then observed a sturgeon at the water surface that exhibited injuries consistent with being struck. However, given the size range of project vessels, it is likely that in most cases vessel operators will not realize they have hit a sturgeon. We expect that having a lookout on project vessels to scan the water to look for sturgeon would increase the likelihood of detection of a struck sturgeon. However, this is most likely to be successful for shallower draft vessels where the fish is struck fairly close to the surface. On deeper draft vessels where the strike would occur further from the surface, it is less likely that a lookout would see a struck sturgeon, particularly if it did not surface quickly. A monitoring methodology similar to what was put in place for pile driving (i.e., using a small boat with trained observer operating on transects looking for dead or injured fish) would be a good supplement to placing lookouts on vessels. We know that this methodology is successful at documenting dead sturgeon as a number of sturgeon were observed with this method during pile driving. The combination of lookouts on vessels and the use of a monitor on a vessel running transects in the vessel impact area (as defined in section 7.4, the area from RM 12-34, which is the area, based on drift models, that it is reasonable to expect a sturgeon struck by a project vessel would be located within 48 hours of being struck) would have a high likelihood of detecting sturgeon struck by project vessels.

However, a significant complication to this monitoring strategy is the number of non-project vessels in the area. If a vessel operator felt a strike and the fish was quickly observed, it would be reasonable to conclude that the fish was struck by that vessel. However, if a lookout observed a fresh dead sturgeon and there were non-project vessels operating in the area it would be difficult to determine which vessel caused the strike. In the event that a non-fresh dead sturgeon was observed, it becomes more complicated. If the fish is suitable for a necropsy, we would know if vessel strike was a likely cause of death. A drift analysis could tell us approximately where the fish drifted from. If that area was one in which only project vessels operated, we could conclude that the strike was caused by a project vessel. However, if it was also an area where non-project vessels operated, it would be difficult to determine which vessel struck the sturgeon.

This issue is further complicated by the fact that some sturgeon may be struck after they are dead and by uncertainty in the characteristics of vessel strike injury. For example, if a moderately decomposed sturgeon was detected in the vessel impact area missing its tail, it may be impossible to determine if the tail was removed while the fish was alive (which would suggest vessel strike) or after it died (in which case the cause of death would not be vessel related). Analysis for other species (manatees; Rommel *et al.* 2007) as well as adult Atlantic sturgeon (Balazik *et al*. 2012) relies on the location of propeller marks to help determine if a strike was pre- or post-mortem (assuming that propeller marks on the belly would only occur if the animal was already dead and floating upside down); however, if vessel strikes are resulting in sturgeon losing tails or being decapitated, this methodology would not work to determine whether a strike occurred pre or post-mortem. Some work has been done with sea turtles (see STSSN 2009) to help determine if injuries, including vessel strike, occurred pre or post-mortem but to date no similar work has been done for sturgeon and we do not have enough information to determine if the methods used for sea turtles would be transferable to sturgeon.

Given these complications it is important to document as many dead sturgeon in the vessel impact area (as defined in section 7.4 as RM 12-34) as possible. Below, we require Reasonable and Prudent Measures and implementing Terms and Conditions designed to maximize the likelihood of detecting sturgeon struck by project vessels. This includes requiring lookouts on project vessels and requiring monitoring for the presence of any floating dead or injured sturgeon in the impact area.

For all dead sturgeon collected in the vessel impact area, we would need to determine the cause of death. For fresh dead sturgeon, necropsy is appropriate and will be required. The necropsy protocols already in place for the project would allow for reasonable determinations of whether a sturgeon was killed by a vessel. However, we recognize that outside of cases where the strike was observed, it will be very difficult to determine the particular vessel that hit the sturgeon. This is addressed below. For sturgeon that are not suitable for full necropsy, the fish will need to be examined to assess and document any injuries and an expert will determine the cause of death based on best professional judgment. At this time we are not aware of any other factors that would result in a sturgeon losing a tail, being cut in pieces, or being beheaded other than vessel strike and will assume that sturgeon presenting with those types of injuries have been struck by a vessel. Predation by seals (likely only on small sturgeon and not adult Atlantic sturgeon), could result in a maimed carcass; however, we have no information to indicate that seal predation on sturgeon is common in the Hudson River or that it would result in sturgeon losing a tail, being cut in pieces or being beheaded. Sturgeon carcasses with propeller marks only on the belly will be assumed to have been struck post-mortem (Balazik *et al.* 2012). We do recognize the potential difficulty in determining if the strike occurred pre or post-mortem and recognize the need to make this determination on a case by case basis. However, for purposes of this consultation, in the absence of a foundation to determine that the strike occurred post-mortem, the worst-case assumption will be made that the strike caused or contributed to the cause of death.

As noted above, if a strike by a project vessel is observed, that strike will be attributable to the project. For sturgeon where the strike is not observed, we will assign the cause of the vessel strike proportionally to vessels operating in the vessel impact area. That is, in cases where the vessel cannot be identified, we will assume that 16% of those strikes were caused by project vessels (because up to 16% of vessel traffic in the area is attributable to project vessels as explained above). This means that we would assume that one out of every six sturgeon where the strike was not observed is attributable to a project vessel and this ITS.

Using this rationale, we will consider take to be exceeded in any of these circumstances:

1. More than six sturgeon are observed to be killed or injured by project vessels; or.
2. More than thirty-eight (16% of 38 = 6) sturgeon are killed or injured in the vessel impact area (RM 12-34) with a cause of death or injury attributable to vessel interactions; or
3. Some combination of the above occurs that indicates that more than six sturgeon have been killed or injured with a cause of death or injury attributable to project vessel interactions (e.g., three are observed to be killed by project vessels and 19 other vessel struck sturgeon are observed); or
4. The total number of projected vessel hours for the remainder of the project (196,940 hours) is exceeded.

We considered a number of measures to minimize the amount or extent of take. We considered measures that we thought could reduce the number of sturgeon struck by project vessels or reduce the severity of the interaction such that serious injury and mortality were unlikely. Below, we present the various measures that we considered.

It is reasonable to anticipate that the more vessels that are operating in an area the greater the likelihood that a sturgeon would be struck. As noted above, the project is using 39 vessels with propellers. We discussed with FHWA the potential to reduce the number of project vessels and/or their operating time to reduce the number of hours that project vessels would be operational in the action area. FHWA has indicated that the number of trips is directly related to the number of crafts, people, materials and equipment necessary to build the bridge, and the contractor has minimized the number of trips by pre-fabricating materials on land as much as possible. FHWA notes that the number of vessel trips has also been reduced through the use of temporary work platforms in the shallowest areas of the project area. FHWA determined that the number of trips cannot reasonably be reduced further and the number of vessels cannot be reduced because they are all operating at maximum load (people or supplies).

We have reviewed the information that FHWA provided on the number of vessels and the number of vessel trips. We have no information to indicate that fewer vessels could be used to transport people or materials to the construction site and no information to indicate that vessels are not being used to capacity and that fewer trips could be used to transport people and materials. As such, if the number of vessels was reduced or the number of trips per day was reduced, it would take more days on the water to complete the project, and there would not be an actual reduction in the number of vessel hours. Therefore, because vessels are already operating as efficiently as possible (that is, their use is scheduled to reduce the number of hours they are operational by maximizing the people and materials transported), it would not be reasonable to require a reduction in the number of vessels or number of trips.

One of the factors that may increase the risk of an interaction is the amount of clearance between vessels and the bottom; we anticipate that a small amount of clearance would minimize the likelihood that a sturgeon could escape and therefore, increase the likelihood of exposure. Therefore, we considered the potential for increasing the amount of clearance between project vessels and the bottom. Additional dredging could be carried out in the vessel impact area; however, this could result in direct mortality of sturgeon due to interactions with the dredge. Additionally, dredging, particularly in the shallows, could result in significant loss of foraging habitat. Therefore, while in theory dredging could reduce the likelihood of vessel strike it comes with additional negative effects that we expect would outweigh any benefits. We considered the potential for using different project vessels that would have a shallower draft. However, the draft of all but one project vessel is already less than 6' which is on the low end for vessel traffic in the Hudson River. Excluding the contractor tug that makes deliveries to and from Coeymans, the only other project vessel with a deeper draft is the tug making deliveries from Tompkins Cove which has a 9' draft; however, that vessel rarely operates outside the navigation channel where depths are at least 30'. Given the already shallow drafts of project vessels and given that we do not know how much clearance is necessary to increase the likelihood a sturgeon could escape (and therefore, minimize take), reducing vessel draft is not reasonable and prudent nor necessary or appropriate to minimize take.

An alternative to reducing vessel drafts would be reducing or eliminating operations in the shallows outside of the navigation channel. However, project vessels need to move through these areas to get to and from the shoreline where they are stored and where they load and offload people and supplies. Restricting vessel operations from waters outside the navigation channel could minimize take if the risk of interactions is higher in the shallows. However, preventing vessels from operating in the shallows would be more than a minor change to the project. It would likely involve relocating staging areas (and/or constructing new staging areas) and could result in an increase in vessel hours if crew and supplies had to be brought in from locations further away. Additionally, it is improbable that we could find a place where crew and supplies could load and unload along the Hudson River and not transit through shallow water. For these reasons, preventing vessels from operating in the shallows is not reasonable and prudent nor necessary or appropriate to minimize take. Similarly, preventing the use of any project vessels would be more than a minor change, and it would result in it being impossible to complete the proposed action.

The best available information indicates that sturgeon are hit by both boat hulls and propellers. We do not know the proportion of strikes of either kind and do not know if one is more lethal than the other. In addition to measures that would minimize the likelihood of any vessel interaction generally, we considered two measures that could minimize the likelihood of an interaction with a propeller (propeller cages and jet drives). Assuming that a strike by a hull rather than a spinning propeller could be less likely to be lethal (as it may not result in a laceration that results in loss of a tail or decapitation), reducing the likelihood of interactions with a propeller could reduce the extent of take by reducing the number of lethal interactions (but possibly not reducing the number of interactions in general).

Propeller cages or guards are designed to minimize contact with the propeller and people or animals in the water. However, it is critical to note that a propeller cage does not prevent vessel strike, it only serves to minimize the likelihood of contact with the spinning propeller. The sturgeon would still be struck by the cage itself. We did not find any literature assessing the impact of propeller cages on the degree of injury for fish. Several sources (Chample and Renilson 2009, Work *et al.* (2010) indicate that at low speeds (less than 10 mph (8.7 knots)) there is less soft tissue and bone damage to test specimens (loggerhead sea turtles) compared to being hit with a propeller without a propeller cage. However, at higher speeds (above 10 mph), a strike from either a propeller cage or a propeller is likely to result in serious injury or mortality. Work *et al.* (2010) examined the damage to prototype sea turtle carcasses struck by conventional outboards, outboards with two different propeller guard systems and when replacing the conventional outboard with a jet outboard motor. They conclude that a standard motor, with or without propeller guards, yields a high likelihood of catastrophic injuries, particularly at planing speeds. At idle speeds, the guards provided some benefit by reducing the likelihood of propeller cuts. They also conclude that while the guards provide some protection from the spinning propeller, they increase the projected area of the motor foot approaching the animal. We discuss the potential for project vessels to operate at lower speeds below. The best available information indicates that the use of propeller guards/cages could reduce the extent of take for interactions with slower moving vessels by preventing exposure to the propeller. Blunt force trauma could still occur, and we do not know if there would be any particular reduction in likelihood of death; however, it is reasonable to expect that a sturgeon is more likely to recover from being hit by a slow moving blunt object than the spinning propeller of that slow moving vessel, particularly if this avoided a laceration from which a sturgeon could bleed out or lose its tail and prevent effective mobility. Given this information, it is possible that requiring propeller cages on the 12 slower moving tugboats could minimize take.

We discussed this with FHWA. FHWA indicates that the installation of propeller cages on project tug boats could cause a restriction and reduction in water flow to the propellers (i.e., cavitation), which may result in a loss of thrust and maneuverability of the boat. They state that maneuverability of project tugs during docking and close-quarters movement within feet of the existing bridge and new bridge is critical to the safety of work crews and to the timely completion of tasks such as lifting steel girders into place, which requires precise movements by project tugs. FHWA states that without the essential level of maneuverability and vessel control, there is an increased risk of vessel collision with other vessels, barges, equipment or bridge structures. FHWA highlights that the nature of the activities performed by tug boats within the project area is intrinsically different from activities performed by tug boats on other commercial operations, such as the long distance movement of barges where propeller cages may be used. They state that, unlike the work in the project area, the movements of tug boats used on other commercial operations are limited, specific, and generally repeatable in nature; their movements approaching the docking facilities are specifically coordinated ahead of time and repeatable with limited changes. In contrast, tug operations in the project area require shifting from forward to astern frequently and in some cases up to 50% of the time the boat is going astern, while making up to 20 to 30 movements per day. Most movements by project tugs are not choreographed or repeatable in nature and are often performed in close proximity to other vessels, barges, equipment and/or bridge structures. FHWA states that this differentiation in movements and tasks is why propeller cages could be installed safely on some commercial tugboats but not the ones operating at the project.

FHWA has objected to the use of propeller cages to project tug boats as a reasonable and prudent measure because of an increased safety risk to project employees. They also state their position that the addition of propeller cages to the hull would increase the draft/surface area of the vessel, making the vessel less avoidable by sturgeon, and increasing the potential of injury or mortality due to blunt force trauma. We have completed an independent review of the statements made by FHWA. We have found examples of where commercial tugboats have been outfitted with propeller cages to either minimize risks to marine animals or fouling of lines on the propeller. However, it appears that FHWA's statements about those vessels carrying out different duties (i.e., escorting other vessels along transit routes) than the Tappan Zee project tugs is true. We also found several references that support FHWA's concerns about propeller cages resulting in decreased maneuverability (Boat U.S. 2012, Royal Yacht Association 2013). Based upon our review, we agree that propeller cages on project tugs are likely to affect vessel maneuverability and result in a safety risk at the project. As such, we agree with FHWA that the use of propeller cages on project tugs is not an appropriate reasonable and prudent measure.

The best available information indicates that at planing speeds the impact to the struck animal is likely to be death regardless of the use of a propeller cage. For these reasons, requiring propeller guards or cages is not reasonable and prudent nor necessary appropriate to minimize take for vessels that operate at planing speed (i.e., all vessels other than the 12 tugboats).

We also considered whether a switch from outboard motors to jet drives would minimize take.

A jet drive propels a boat by a jet of water ejected from the back of the craft. Unlike a powerboat or motorboat that uses an external propeller in the water below or behind the boat, a jet boat draws the water from under the boat through an intake and into a pump-jet inside the boat, before expelling it through a nozzle at the stern. Work *et al.* presents data that support their determination that jet propulsion systems greatly reduced the likelihood of catastrophic injury because they eliminated the spinning propeller. It appears that a switch from outboard motors to jet propulsion could result in different injuries than being struck by propellers (i.e., blunt force rather than slicing) and, if these blunt force injuries were less damaging than propeller injuries could result in a reduction in take by reducing the number of mortalities (although not the number of strikes). We discussed with FHWA the potential conversion of project vessels from inboard and outboard motors to jet drives.

FHWA indicates that installing jet drives on the current fleet of project tugs is not feasible and would require replacement of the tugboats rather than replacing the existing engines with jet propulsion systems. They state that this is because vessels powered by jet drives have a V-shaped hull with a particularized tunnel design to prevent cavitation and loss of thrust and maneuverability, with consequent adverse safety impacts. All but one of the fleet of project tugs have flat-bottomed hulls that are not compatible with jet drives. For this reason, project tugs could not be retrofitted to use jet drives, but would have to be replaced with a new fleet of tugs. FHWA states that because jet-drive tugs are not readily available for purchase; a new fleet of project tugs would have to be custom designed and built; they indicate that the time required to build a new tug with a jet drive and the operational requirements for the project is approximately one year at a cost of $1.8 to $2.2 million per vessel. This would result in a total cost of approximately $24 million dollars to replace the 12 project tugs. FHWA states that replacement of project tugs would result in unacceptable and unreasonable costs and schedule delays.

We reviewed the information presented by FHWA. Information available to us indicates that jet propulsion systems are designed to work on vessels with slight vee-hulls with properly designed tunnels and not on boats with deep vee-hulls or with keels[22]. It is our understanding that the bridge replacement project cannot be completed without the project tugs. Replacing all of the tugs at one time would result in the cessation of all work for one year while new tugboats were built. Reasonable and prudent measures and the terms and conditions that implement them cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes (50 CFR§ 402. 14(i)(2)). Requiring the replacement of the existing tugboats with ones outfitted with jet propulsion systems would result in a significant alteration of the duration and timing of the action (by delaying all work for one year); therefore, we do not consider it a reasonable and prudent measure. We also considered whether tugboats could be replaced one at a time; however, given that there are less than three years of work remaining, only two tugboats could be replaced during that time. We do not expect that the replacement of 2 of the 12 tugboats would result in a reduction in take of sturgeon. For these reasons, requiring installation of jet propulsion systems on project tugs is not reasonable and prudent.

We expect that replacement of outboard prop-driven engines on small crew boats could reduce the likelihood of death to a struck sturgeon by removing the spinning propeller; this replacement

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[22] http://outboardjets.com/boat-selection/

would also reduce the draft of the vessel by removing the outboard motor (located below the water line) which in turn, could reduce take by reducing the likelihood of a collision. We discussed this option with FHWA. FHWA states that replacing outboards with jet drive units would entail a 30% loss of power causing the boats to operate at 80% of the speeds possible with the current outboards. They state that this would result in longer travel times between work sites and ultimately in delayed completion of the project. In order to offset the loss of engine power, a larger jet drive would be needed. The maximum sized engine that could be accommodated by the current fleet of small crew boats is 150 HP; a 175 HP equivalent would be needed to maintain the requisite horsepower level using a jet drive system. Structurally, the transoms of the eight small crew boats are not rated to bear the weight of the larger motor. For the seven large crew boats, which have inboard motors, significant modifications to the below deck space, exhaust system, and other systems would be required to accommodate a jet drive engine. FHWA also states that even if outboard jet drives could be mounted on small crew boats, the existing hulls are not properly shaped (i.e., do not have the properly designed tunneling) to minimize the introduction of air into the system and prevent cavitation. Cavitation would occur in rough/choppy water, which is common in the Hudson River at the construction site, and would reduce power and control of the crew boat. In addition, jet drives are prone to clogging by debris that is entrained at the intake, which would also reduce performance and result in delays in transporting work crews while maintenance to remove the clog is conducted.

FHWA states that the cost and schedule implications associated with the conversion of outboard prop-driven motors on crew boats to jet drives would be approximately $52,000 per vessel (total cost of $416,000) and one to two-months during which each small crew vessel would be out of service and unable to transport crew to the work site. They indicate that similar limitations (i.e., loss of thrust, need for significant structural alterations to the hull, hull shape, cavitation, and clogging) would apply to the conversion of the seven large crew boats from inboard engines to jet drives. The cost and schedule implications would be an additional cost of approximately $550,000 per vessel (total cost of $3.85 million) and at least a 3- to 6-month delay to the project, while the existing fleet of crew boats is retrofitted with jet drive units. Because the project is currently running at maximum capacity, removing even one large crew boat from service would require crew layoffs and schedule delays. FHWA concludes that for these reasons, retrofitting the entire fleet of crew boats is not a viable option and that the additional costs and schedule delays would disqualify this as a reasonable and prudent measure.

We have completed an independent review of the rationale and materials provided by FHWA. As noted above, jet propulsion systems are designed to operate on flat or near flat bottomed hulls, not vee-hulls. While we do not have access to the hull ratings of the crew boats, all vessels are sold with a hull rating (see 33 CFR subpart D 183.51-183.53) that indicates the maximum weight of people, motor and gear. Therefore, it is reasonable to expect that replacement of the outboard motors could result in an unsafe increase in weight (above the rated capacity) as indicated by FHWA. This would mean that rather than retrofitting the eight smaller crew boats with jet drives, these vessels would need to be replaced. As explained above, reasonable and prudent measures and the terms and conditions that implement them cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes (50 CFR§ 402. 14(i)(2). Requiring the installation of jet propulsion systems on the fifteen crew boats would result in a cost of at least $4.2 million and a delay in the project of three to six months. Given this, we find that in this case, requiring conversion to jet propulsion, is not reasonable because it would be more than a minor change to this action.

Further, in consideration of requirements related to propeller cages and jet propulsion we reiterate that these measures may not actually result in a reduction in strikes or change the consequences of those strikes. One of the four sturgeon collected by the TZ project team and necropsied was determined to have died due to blunt force trauma, presumably by being hit be a vessel. This indicates that interactions with more than just the propeller can kill sturgeon. We have no information to indicate that being hit by the components of the jet drive, a boat's hull or by a propeller cage would be less likely to result in serious injury or death than being hit by the propeller itself.

Speed is considered to be a risk factor for vessel strike. We expect that sturgeon are more likely to be able to avoid a slower moving vessel and that if hit by a slower moving vessel, the strike is less likely to result in serious injury or mortality. However, we have no information to suggest what speed would result in a decreased risk of strike or decreased risk of serious injury or mortality. Research on right whales indicates that a reduction in speed to 10 knots for vessels 65 feet and longer reduces the likelihood of serious injury and mortality. However, given the massive size of right whales compared to sturgeon and their very different morphology and behaviors, it is not reasonable to rely on a speed restriction developed for right whales and assume a reduced risk for sturgeon. No studies have been carried out to determine a "safe" operating speed for sturgeon. As noted in the Effects of the Action, shovelnose sturgeon are entrained and killed in propellers of towboats in the Mississippi River (Miranda and Kilgore 2013). These towboats operate at speeds of 3.5 – 11mph (3 – 9.5 knots). This suggests that the risk of mortality remains even at slower speeds. Given the lack of available data, we can not recommend a speed that would result in minimization of take, however, we expect that if vessels were restricted to headway speed only (likely 5 knots or less given currents in the river), sturgeon would be more likely to avoid vessels and the risk of interactions would be reduced and take would be minimized. We discussed the potential for requiring vessel speed reductions with FHWA. FHWA has determined that requiring a reduction in vessel speed cannot be considered a reasonable and prudent measure because it would result in more than a minor change to the project. As described fully in a May 13, 2016 submission to us, they have indicated that if all project vessel speeds were reduced to 10 knots or less, beginning on May 1, 2016 and continuing throughout the project, it would result in $66 million in additional direct labor and equipment costs and an additional 159 days to complete the project. Reasonable and prudent measures and the terms and conditions that implement them cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes (50 CFR§ 402. 14(i)(2). A reduction in speed to five knots or less would increase costs even further and would extend the project duration. Given this, we find that in this case, requiring a reduction in speed to five knots, or even ten knots which may not result in a reduction in take, is not reasonable because it would significantly alter the duration the action and therefore would violate the minor change rule. Further, it is unclear if a reduction in speed that resulted in a significant increase in vessel operating hours (at least an additional six months of vessel operations of all 39 project vessels) would actually result in a reduction in take or if any benefits gained by reducing speed would be lost by increasing vessel operating hours.

We could not identify any other measures that could be implemented to minimize the amount of sturgeon expected to be struck by project vessels. As such, in the sections below, there are no reasonable and prudent measures or implementing terms and conditions that would minimize the amount or extent of incidental take posed by project vessels.

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 action to document the amount of incidental take (i.e., the number of shortnose and Atlantic sturgeon 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 or minimize 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 without injuries that affect their ability to swim must be released back into the river, at a safe distance away from the pile driving or other project activities.

We believe the following reasonable and prudent measures are necessary and 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 do not repeat them here as they are considered to be part of the action. For example, FHWA has committed to only driving piles for 12 hours a day, using vibratory methods to the maximum extent practicable; as such, these measures are not repeated in the RPMs and Terms and Conditions below. We consider a failure to implement the Environmental Performance Commitments a change in the action that may necessitate reinitiation of consultation. 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 Pile Driving Activities:

1. FHWA must monitor underwater noise during the installation of a representative number of piles during each group of piles remaining for 2016 and 2017.

2. FHWA must continue to implement a program to monitor impacts to sturgeon resulting from pile installation.

RPMs for Vessel operations:

3. FHWA must monitor and report the number of hours that project vessels operate.
4. FHWA must require that the captain or crew on every vessel transit look for sturgeon that may have been struck by vessels.

5. FHWA must implement a monitoring plan designed to detect dead or injured sturgeon in the vessel impact area (RM 12-34).
6. FHWA must implement a VEMCO Positioning System (VPS) study designed to monitor the movements of tagged shortnose and Atlantic sturgeon in relation to project vessel 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 avoids the additional risk of death or injury. Fish with injuries that likely impair their swimming ability must be held in a livewell until disposition is discussed with NMFS.

8. All Atlantic sturgeon captured must have a fin clip taken for genetic analysis.

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, FHWA must monitor the peak noise and size of the 206 dB re 1uPa isopleth during each of the ten pile installation sets remaining in 2016 and 2017. This will involve monitoring a representative sample of no less than two piles in the following sets:

Week (Year)	Pile Diameter	Area/Section	Total No. Piles
17 (2016)	3	Pier 2 EB	15
20 (2016)	3	Pier 3 EB	15
22 (2016)	3	Steel Erection Falsework - Pier 2 EB	12
24 (2016)	3	Pier 4 EB	14
26 (2016)	3	Rockland South Trestle and Falsework	106
35 (2016)	3	Pier 40 EB	24
38-43(2016)	3	Rockland North Trestles	65
38-43(2016)	2	Rockland North Trestles	6
40 (2016)	3	Pier 39 EB	22
26 (2017)	2	Westchester Trestle and Falsework	64

This will allow for comparison to the information presented in Table 8 in the Opinion. Monthly reports must include the number of piles driven, peak noise, size of the 206 dB re 1uPa isopleth and the duration of pile driving activities (with the impact hammer). This is necessary 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 these piles.

2. To implement RPM #2, 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 ensure that someone on the barge records actual time of pile driving (including the beginning and end times and pile size) for impact hammering. If vessel based transect monitoring is occurring on the day of pile driving (see RPM #5), no additional monitoring is required. If pile installation occurs on a day transect monitoring is not occurring and water temperatures are above 8°C, vessel based monitoring must occur as detailed in Appendix A.
3. To implement RPMs #2, 4 and 5, if FHWA determines that changes to any monitoring plan are necessary, FHWA must submit a revised plan to NMFS and request concurrence with the proposed modifications. 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 may 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.
4. To implement RPM #3, FHWA must report the monthly and cumulative number of operating hours for project vessels to NMFS within 30 days of the end of each month (e.g., hours for June 2016 must be reported to NMFS no later than August 1, 2016).
5. To implement RPM #4, every project vessel must have at least one person looking out for sturgeon on every vessel trip. On every trip, one person must be designated as responsible for the observation of, and response to, any dead or injured sturgeon or vessel interactions with sturgeon within the construction area (RM 26-29). Signs bearing a picture of both sturgeon species and contact information must be posted aboard each project vessel as a reminder for project personnel to report dead or injured sturgeon. Additionally, all project

personnel that routinely work on the water, including vessel captains and crew must be trained annually to identify and report dead and injured sturgeon that are observed within the construction area. Vessel captains, crew, and project supervisors must receive the first annual training session within 30 days of the date of issuance of this Biological Opinion.

6. To implement RPM #4, all sturgeon observed by the lookout vessels must be reported to the designated biologist immediately. GPS coordinates must be reported and recorded as well as the direction of tidal flow. The on-site or on-call biologist would come and take possession of the carcass as soon as possible (e.g., within 30 minutes of the report). A report would be made to FHWA and NMFS within 24 hours. In the event that a fish is struck and is not dead, or an injured sturgeon is observed, the vessel must stop operations (except in emergency situations where doing so would be unsafe), notify the on-site or on-call biologist and stand by until the fish can be collected and retained in a livewell.
7. To implement RPM #5, FHWA must ensure the vessel impact area is monitored for the presence of any floating dead or injured sturgeon from April 1 (or when water temperatures reach 8C for 24 hours, whichever is sooner) through November 30. FHWA must implement the plan detailed in Appendix A to ensure the detection and collection of floating stunned, injured or dead sturgeon. The plan must be implemented within one week of transmittal of this final Opinion to FHWA. Sturgeon observed must be reported as required below.
8. To implement RPM #5, if any dead or injured sturgeon are documented in the vessel impact area between December 1 and March 31, FHWA must discuss the need to carry out boat-based surveys consistent with the protocol outlined in Appendix A. The decision to require boat based surveys following the detection of a dead or injured sturgeon between December 1 and March 31 will be made by NMFS and will take into account water temperature and other relevant information regarding the presence of sturgeon in the area (e.g., detections of tagged sturgeon) as well as weather conditions that may impact the safety of the crew.
9. To implement RPM #6, FHWA must undertake an analysis of sturgeon detection data collected from the NYSTA’s near-field receiver array (during sturgeon monitoring at the Tappan Zee Bridge from 2013-2015) in comparison with AIS vessel-position data to better understand how sturgeon respond to vessels in the project area. The available data consists of over 800,000 sturgeon detections, approximately 30,000 sturgeon positions, and approximately 1,000 cases in which an individual sturgeon was tracked moving through the construction area. Each of these cases must be analyzed to track the movement of individual sturgeon in relation to vessel traffic in the construction area. A draft report must be provided to us by September 30, 2016.
10. 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. Fish that are not dying and can swim unimpaired must be released back into the river. Fish with significant injuries must be held in a livewell until disposition is discussed with NMFS
11. To implement RPM #8, FHWA must ensure that fin clips are taken (according to the procedure outlined in Appendix B) of any sturgeon captured during the project. In the case of dead animals, fin clips must be taken prior to preservation of other fish parts or

whole bodies. All fin clips must be preserved (see Appendix B) and transported to a NMFS-approved lab. FHWA must coordinate with the qualified lab to process the sample in order to determine DPS (for Atlantic sturgeon) of origin. The DPS or river of origin must be reported to NMFS once the sample has been processed. FHWA must make arrangements with an appropriate individual/facility within 30 days of receiving this Opinion. The arrangement must be memorialized via letter to NMFS from FHWA that includes information on arrangements for the frequency of transfer of samples to the facility and timelines for processing of samples. A portion of the fin clip must be sent to the sturgeon genetics archive currently housed at the USGS facility in Leetown, West Virginia (see Appendix B).

12. To implement RPM #9, FHWA must ensure all collected sturgeon are 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 C. Injured fish must be visually assessed, measured, photographed, released away from the site and reported to NMFS.
13. 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 D must be completed and submitted to NMFS.
14. 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 D) 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 observation. FHWA must also ensure that every sturgeon is photographed. Information in Appendix E 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 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 collected during the bridge replacement project. The discussion below explains why each of these RPMs and Terms and Conditions are reasonable and prudent and necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action. As explained above, RPMs and the terms and conditions that implement them cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes (50 CFR§ 402. 14(i)(2)). Several of the RPMs identified herein are costly to implement; however, we have determined, and FHWA has agreed, that none of these alter the basic design, location, scope, duration or timing of the action and do not involve more than minor changes to the proposed action.

RPM #1 and its implementing Terms and Conditions 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. While this RPM is costly to implement, we have determined, and FHWA has agreed, that this RPM does not alter the basic design, location, scope, duration or timing of the action and does not involve more than minor changes to the proposed action.

RPM #2 and its implementing Terms and Conditions are necessary and appropriate because they will monitor direct impacts to sturgeon during pile installation. This monitoring protocol, that will continue to be implemented in association with pile installation, is 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.

The purpose of Term and Condition #3 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 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 #3 and its implementing Terms and Conditions are necessary and appropriate to track the number of hours that project vessels are operating which is related to monitoring the amount of take. Because our calculation of take is tied to the number of hours that vessels will operate, it is critical that monitoring and reporting of hours take place. This represents only a minor change as collecting and reporting this information will have an insignificant impact on the cost of the project and will not result in any delays.

RPM #4 and its implementing Terms and Conditions are necessary and appropriate to minimize and monitor take. It is possible that having a lookout on every vessel trip will result in avoidance of some sturgeon (if the sturgeon are near the surface, seen and can be avoided) and therefore, minimize take; however, the primary purpose of this RPM is to monitor the amount of take in the area where project vessels operate by ensuring that every project vessel has someone looking out for any sturgeon. This allows us to monitor the amount of take resulting from the proposed action and provides adequate year-round monitoring in the area transited by project vessels for sturgeon that may have been struck by vessels. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and any delays will be limited to the time necessary to respond to a dead or injured individual.

RPM #5 and its implementing Terms and Conditions are necessary and appropriate to monitor take. RPM #4 and its implementing Term and Condition will result in year-round monitoring in the area where project vessels travel. However, we know that dead sturgeon can drift outside of this area. Therefore, it is critical that the vessel impact area (the area where we can reasonably expect to detect a sturgeon struck by a project vessel within 48 hours) also be monitored. The vessel impact area is not an overwintering area for shortnose or Atlantic sturgeon; therefore, it is reasonable to use 8°C as a trigger for beginning transects in the spring as that is when shortnose and Atlantic sturgeon begin to leave overwintering grounds in the Hudson River (Dovel *et al*. 1992) and could be expected to move into the Tappan Zee reach. The number of sturgeon in the project area is very low during the winter months. Of the 52 tagged shortnose sturgeon detected on the receiver array, eight were detected in November and only two were detected from December – March. No Atlantic sturgeon were detected from January – March and 17 out of 361 tagged Atlantic sturgeon were detected in November. Transects will be run three days per week (approximately every 48 hours) from April through November. This means that the only monitoring that will occur from December – March will be via the lookouts on the project vessels. However, the best available information indicates that very few sturgeon are present in the project area from December – March (NYSTA reports that no tagged Atlantic sturgeon and only two shortnose sturgeon have been detected on the receiver array during these months). Further, no dead or injured sturgeon have been documented in the vessel impact area during these months. Based on this information, the risk of strike appears to be very low in the December- March period and requiring monitoring via the lookouts is sufficient to monitor any take that may occur during this time of year. However, in the event that a dead or injured sturgeon is documented in the vessel impact area during the December – March period, we will determine if transects should be required to determine if other dead or injured sturgeon are present in the vessel impact area. During the April – November period, requiring transects every 48 hours is appropriate because, based on the drift analysis, any sturgeon struck and killed by a project vessel should remain within the vessel impact area for at least 48 hours. While this RPM is costly to implement, we have determined, and FHWA has agreed, that this RPM does not alter the basic design, location, scope, duration or timing of the action and does not involve more than minor changes to the proposed action.

RPM #6 and its implementing Terms and Conditions are necessary and appropriate to determine the behavioral response of sturgeon to vessels in the project area. We expect that the information obtained from the VPS study will allow for detection of any behavioral responses associated with vessels equipped with AIS. This information can then be used to validate the assumptions made in this Opinion that contributed to the take estimate and potentially develop future terms and conditions to minimize take associated with project vessels. This represents only a minor change as analyzing data that has already been collected will have an insignificant impact on the cost of the project and there will be no delays.

RPM#7-9 and the implementing Terms and Conditions are necessary and appropriate to 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 for genetic analysis to confirm species ID and 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. We have 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 its implementing Terms and Conditions 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 its implementing Terms and Conditions 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, we recommend FHWA consider continuing to implement the following Conservation Recommendations that were recommended in previous Opinions:

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.

Additionally, we recommend that FHWA implement the following conservation recommendations that are specific to better understanding the risk posed by vessel operations:

1. Conduct a sturgeon carcass tracking study. This would address the question of drift following mortality.

2. To assess the risk associated with vessel draft, conduct a vertical positioning study to identify the duration of time that Atlantic and shortnose sturgeon spend at different depths within the water column. Satellite tags with pressure sensors will be attached on up to 10 sturgeon and each fish will be tracked via satellite. The sturgeon positioning data will then be compared with the drafts of vessels that transited the study area to further refine the type of vessels that pose the greatest risk of vessel strike to sturgeon. Vessel speeds will be summarized for that subset of vessels. The goal of this study would be to determine how far off the bottom sturgeon occur while migrating or moving between foraging or resting areas and whether there are lifestage or species differences and whether there are differences in vertical distribution correlated to water depth (i.e., do sturgeon stay closer to the bottom in shallower waters). This information would help to address data gaps that are important to assess where sturgeon may be at highest risk of vessel strike, the extent that vessel draft and water depth are risk factors and address significant question related to sturgeon vessel mortality and risk of vessel strike.

3. Conduct a study to characterize certain risk factors posed by commercial vessels as they relate to Atlantic sturgeon mortalities in a portion of the Hudson River. Risk factors to be considered include: vessel draft, vessel speed, and propeller dimensions. The proposed study is intended to investigate watercraft injuries to sturgeon with the goal of identifying the type of watercraft that may result in injury and mortality, and determine if there is a type or size of vessel that is more likely to result in mortality. The study results could also be useful for predicting vessel size and/or type from wound characteristics based on propeller size. The study is expected to be performed in either 2016 or 2017.
    a. Information on commercial vessel operations (i.e., number and frequency of vessel trips, vessel speed), hull and propeller characteristics will be obtained from the Automatic Identification System (AIS) vessel database. Wherever necessary, supplemental research will be performed to collect information on vessel draft, speed, and propeller size.

    b. To assess the risk associated with propeller size, the researchers will collect morphometric data including total length, girth and body depth, as well as the dimensions and description of any injuries, from sturgeon reported in the study area. Researchers will respond to reported sturgeon mortalities observed in the study area to obtain these measurements from vessel related sturgeon mortalities. Those data will then be used to relate propeller-blade length to sturgeon body size, which will provide an indication of the minimum propeller size that could have caused the observed injuries. Propeller size will then be compared to the vessels that transited the study area during the study period to identify vessels most likely to have caused the mortality.

[STILL NEED TO ADD REINITIATION LANGUAGE]

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APPENDIX A

Procedures for Pile Driving Monitoring on Days when Vessel Based Surveys are not being carried out in the Vessel Impact Area

A small vessel will be used as an observation platform during pile driving activities to search for stunned or dead sturgeon and non-sturgeon species within 1.0 mile down-current of the operation, based on anticipated pile driving times and peak current velocities. The vessels will be equipped with a Global Positioning System (GPS), VHF radios, and depth sounders. The vessel-based monitors will search transects within 1 mile downcurrent of pile driving activity during and up to one hour after pile driving has been completed, conditions permitting. The vessel will run a pattern around pile driving activities that will allow visual observation of the construction zone and down-current of the construction zone, including shoreline areas as appropriate depending on the water depth at the time of inspection. Each transect will be recorded by GPS. Location and vessel speed will take into account physical conditions such as tide, wind, visibility, and precipitation, in order to maintain adequate visual coverage within the 1-mile radius downcurrent of the pile driving activities. Surveys could include patterns such as sawtooth or circular patterns, to provide adequate coverage of the activity. The observers from the vessel will scan the water with binoculars, as practicable. When vessel-based monitoring occurs, one scientist will be a designated look out. Vessel-based monitoring may be temporarily suspended due to weather or other safety concerns and will not occur prior to sunrise or after sunset.

Protocol for vessel transect surveys within the vessel impact area (RM 12-34)

Background

The objective of the transect surveys is to monitor the vessel impact area (RM 12-34) for dead and injured sturgeon to maximize the likelihood of detecting recent (within the previous 48 hours), vessel-related sturgeon mortalities. This monitoring will allow FHWA to track the number of mortalities and allow NMFS and FHWA to determine if the exempted amount of take is exceeded.

Basis of the Vessel Transect Surveys

Based on a drift analysis using river current velocity and tidal stage, a sturgeon struck by a vessel at Petersen's Marina (RM 29) on a low slack tide, could drift approximately 5 miles upstream on the rising tide to Croton Point (RM 34). A sturgeon struck by a vessel at the downstream end of the construction area (RM 26) on a high slack tide could drift approximately 13 miles downstream over a 48-hr period, by which time it could have reached the George Washington Bridge (RM 12). Therefore, a monitoring program that covers this area (RM 12-34) every 48 hours is likely to detect a floating sturgeon that was struck by a vessel in the construction area (RM 26-29).

Vessel surveys will begin in the spring within 48 hours of river temperatures reaching 8°C[23] for 24 hours as measured at the Hudson River Environmental Conditions Observing System

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[23] Atlantic and shortnose sturgeon begin leaving the overwintering grounds when spring water temperatures reach a sustained 8-9°C (Dovel et al. 1992).

(HRECOS) hydrological station at Piermont Pier (on or about April 1). Vessel surveys will be conducted three times per week, or every 48 hours, between Monday and Saturday (assumes no vessel operations on Sundays).

The Tappan Zee project area is not an overwintering area for shortnose or Atlantic sturgeon. Monitoring intensity will be seasonally variable based on two sources of data that support the conclusion that very few shortnose and Atlantic sturgeon occur in the Tappan Zee project area during the winter (December – March): 1) the frequency of detections of acoustic-tagged sturgeon in the Thruway Authority's near-field acoustic receiver array from 2013-2015, and 2) the frequency of reported sturgeon mortalities from 2012-2015. During near-field telemetry monitoring between 2013 and 2015:

- Less than 1% of sturgeon detections occurred during January-March, and sturgeon were not detected at all in 2015 between January and March.
- Approximately 98% of sturgeon detections occurred during April through November.
- Less than 2% of all detections occurred between December and March.
- Of the 52 tagged shortnose sturgeon detected on the receiver array, eight were detected in November and only two were detected from December – March.
- No Atlantic sturgeon were detected from January – March and 17 out of 361 tagged Atlantic sturgeon were detected in November.
- Reported sturgeon mortalities in the NYSDEC database between 2012 and 2015:
    - 98% of all sturgeon mortalities (vessel- and non-vessel related) from 2012-2015 were reported between April 1 and November 30 in both the river and the impact area (RM 12-34).
    - During each year, 100% of **vessel-related** sturgeon mortalities reported in the NYSDEC database within the vessel impact area (RM 12-34) were reported from May through October.

Monitoring for dead and injured sturgeon floating in the river or washed up on the shoreline between RM 12 and 34 will consist of vessel transects conducted by a dedicated monitoring vessel with a minimum of two dedicated staff. Because the monitoring effort by project personnel in the construction area (RM 26-29) will consist of project-trained observers on up to 30 project vessels, any additional effort by a dedicated monitoring vessel within the construction area will not significantly increase the likelihood of detecting a dead or injured sturgeon within the construction area. Therefore, vessel transect surveys will focus on river and shoreline areas outside of the construction area and will only conduct shoreline monitoring within the construction area.

<u>Monitoring Protocol</u>

Vessel surveys will consist of a series of shoreline and offshore transects conducted by the two-person team on the monitoring vessel. Vessel surveys will be conducted three times per week, or every 48 hours, between Monday and Saturday (assumes no project vessel operations on Sundays) between April 1 (or when water temperatures reach 8°C for at least 24 hours,

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whichever is earlier) and November 30, as river and weather conditions permit safe operations as determined at the discretion of the vessel captain. During each monitoring day, the following survey routine will be performed (Figure 1), as river and weather conditions allow:

- Shoreline transects will be run within 100 meters of the shoreline or close enough to shore that the observer can identify any sturgeon that have washed ashore.
- Offshore transects will consist of a longitudinal transect along the centerline of the river, as well as a series of zig zags back and forth across the river as the monitoring vessel moves in an upstream or downstream direction.
- Upstream of the construction area, the monitoring vessel will run one shoreline transect up one side of the river towards Croton Point, cross the river, and run a second shoreline transect down the opposite shoreline towards the construction area. Then the monitoring vessel will run an offshore transect up the middle of the river towards Croton Point and will perform a zig-zag transect from Croton Point back to the construction area. Within this reach, approximately 35 miles (30 nautical miles) will be covered during each survey.
- Downstream of the construction area, the monitoring vessel will perform a similar series of transects as those performed in the upstream reach. Within this reach, approximately 80 miles (70 nautical miles) will be covered during each survey.
- Within the construction area, both shorelines will be surveyed for sturgeon. Within this reach, approximately 11 miles (10 nautical miles) will be covered during each survey.
- On any days that the captain determines conditions are unsafe, NMFS must be informed as soon as possible. The survey must be rescheduled as soon as conditions become safe.
- If a complete survey is not completed, NMFS must be informed as soon as possible.

Reporting

FHWA will submit a monthly monitoring report that summarizes the number of operating hours for project vessels, a statement of the number of dead or injured sturgeon observed within the construction area, a summary of dates for vessel transects, start and end times, number and locations of transects completed, and number of dead or injured sturgeon observed within the vessel impact area. This report will be provided within 30 days of the end of the month.

Dead or injured sturgeon sighted during this monitoring program will be reported to NMFS immediately. Each case will be documented and a report submitted to NMFS as detailed in the Sturgeon Sighting Protocol. Sturgeon that are determined to be suitable for necropsy will be transported to Cornell and processed according to the Sturgeon Necropsy Plan. A necropsy report will be submitted to NMFS upon completion. Injured sturgeon will be handled according to the requirements of the Biological Opinion.

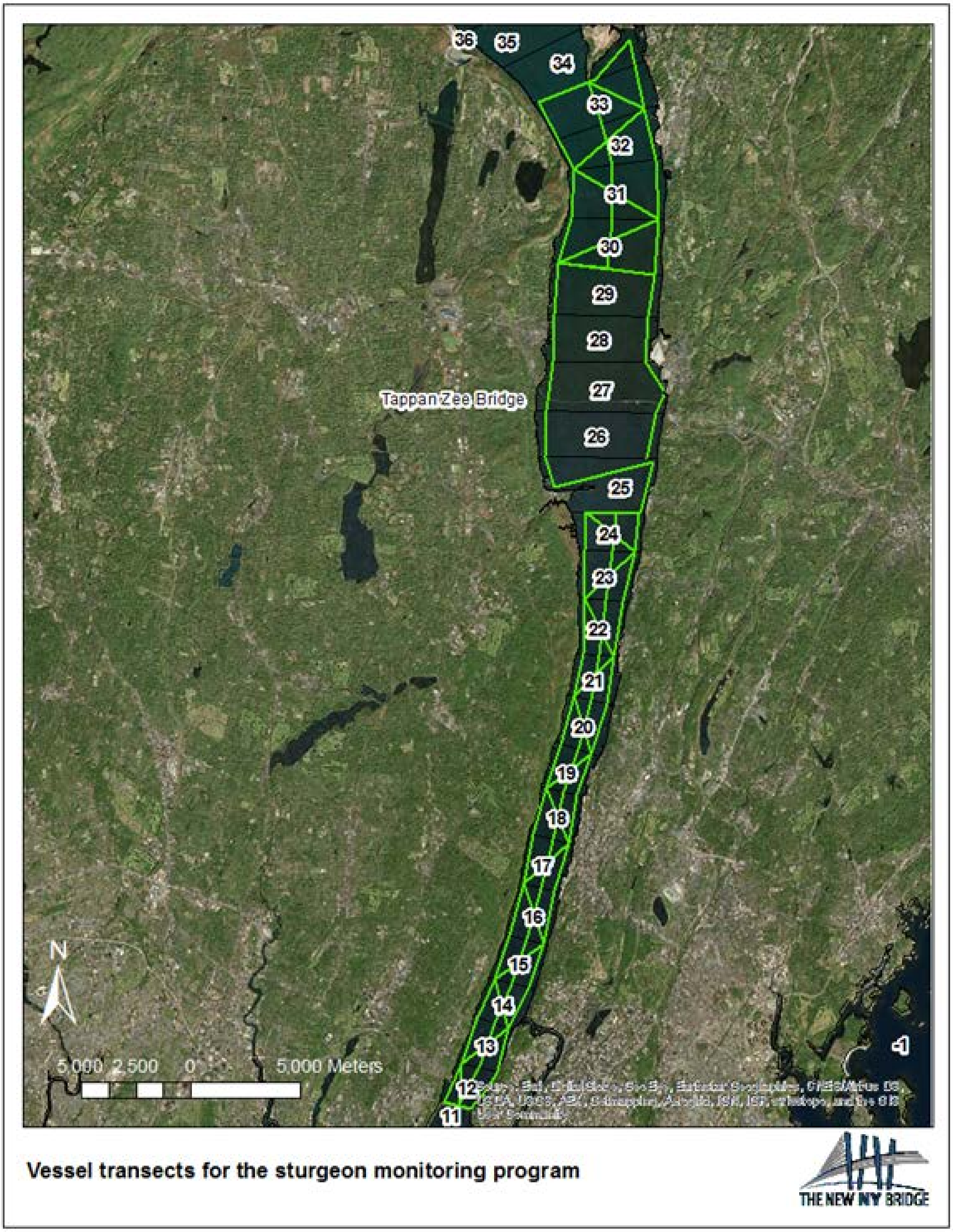


Figure 1. Vessel transects to monitor for dead and injured sturgeon in the vessel impact area (River Miles 12-34).

APPENDIX B

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

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

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

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

Storage and Sending of Sample

1. If possible, place the vial on ice for the first 24 hours. If ice is not available, please refrigerate the vial. Send to the NMFS-approved lab for processing to determine DPS or river of origin per the agreement you have with that facility.
2. A sub-sample of the fin clip must be sent to the Atlantic sturgeon genetics archive at the USGS facility in Leetown, WV.

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

   Dr. Tim King
   USGS Leetown Science Center
   11649 Leetown Road
   Kearneysville, WV 25430

   Prior to sending the sample, contact NMFS Protected Resources Division (978-281-9328) to report that a sample is being sent and to discuss appropriate shipping procedures.

APPENDIX C

PIT Tagging Procedures for Shortnose and Atlantic sturgeon

(adapted from Damon-Randall *et al*. 2010)

Passive integrated transponder (PIT) tags provide long term marks. These tags are injected into the musculature below the base of the dorsal fin and above the row of lateral scutes on the left side of the Atlantic sturgeon (Eyler *et al*. 2009), where sturgeon are believed to experience the least new muscle growth. Sturgeon should not be tagged in the cranial location. Until safe dorsal PIT tagging techniques are developed for sturgeon smaller than 300 mm, only sturgeon larger than 300 mm should receive PIT tags.

It is recommended that the needles and PIT tags be disinfected in isopropyl alcohol or equivalent rapid acting disinfectant. After any alcohol sterilization, we recommend that the instruments be air dried or rinsed in a sterile saline solution, as alcohol can irritate and dehydrate tissue (Joel Van Eenennam, University of California, pers. comm.). Tags should be inserted antennae first in the injection needle after being checked for operation with a PIT tag reader.

Sturgeon should be examined on the dorsal surface posterior to the desired PIT tag site to identify a location free of dermal scutes at the injection site. The needle should be pushed through the skin and into the dorsal musculature at approximately a 60 degree angle (Figure 5). After insertion into the musculature, the needle angle should be adjusted to close to parallel and pushed through to the target PIT tag site while injecting the tag. After withdrawing the needle, the tag should be scanned to check operation again and tag number recorded.

Some researchers check tags in advance and place them in individual 1.5 ml microcentrifuge tubes with the PIT number labeled to save time in the field.

Because of the previous lack of standardization in placement of PIT tags, we recommend that the entire dorsal surface of each fish be scanned with a PIT tag reader to ensure detection of fish tagged in other studies. Because of the long life span and large size attained, Atlantic sturgeon may grow around the PIT tag, making it difficult to get close enough to read the tag in later years. For this reason, full length (highest power) PIT tags should be used.

Fuller et al. (2008) provide guidance on the quality of currently available PIT tags and readers and offer recommendations on the most flexible systems that can be integrated into existing research efforts while providing a platform for standardizing PIT tagging programs for Atlantic sturgeon on the east coast. The results of this study were consulted to assess which PIT tags/readers should be recommended for distribution. To increase compatibility across the range of these species, the authors currently recommend the Destron TX1411 SST 134.2 kHz PIT tag and the AVID PT VIII, Destron FS 2001, and Destron PR EX tag readers. These readers can read multiple tags, but software must be used to convert the tag ID number read by the Destron PR EX. The FWS/Maryland Fishery Resources Office (MFRO) will collect data in the coastal tagging database and provide approved tags for distribution to researchers.

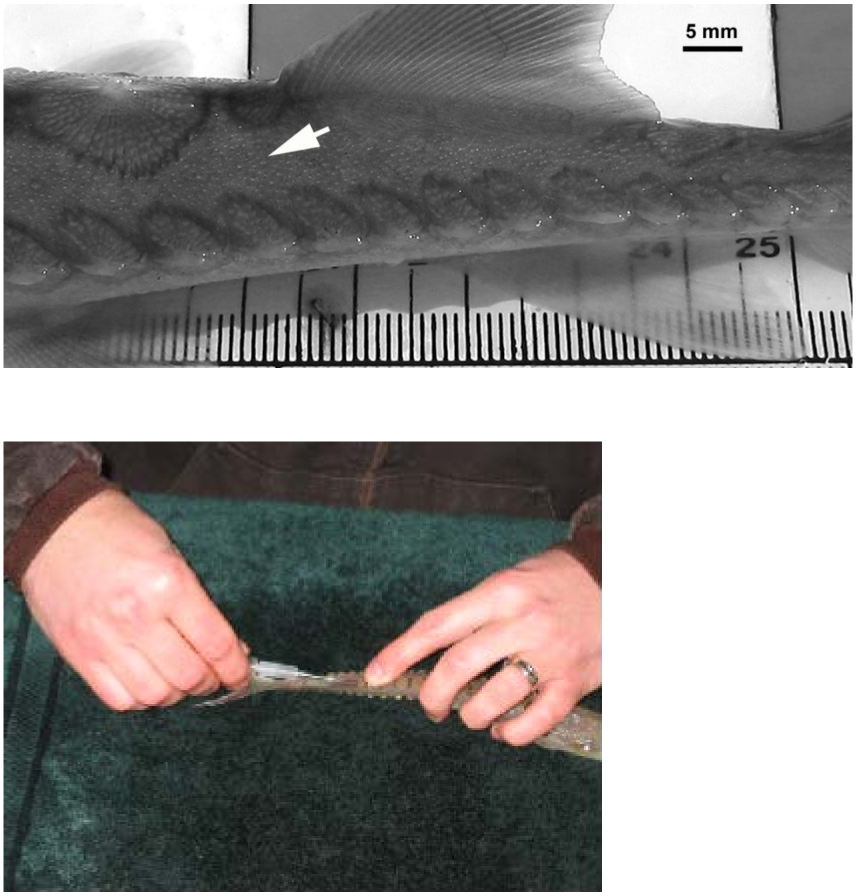


Figure 5. (from Damon-Randall *et al*. 2010). Illustration of PIT tag location (indicated by white arrow; top), and photo of a juvenile Atlantic sturgeon being injected with a PIT tag (bottom). *Photos courtesy of James Henne, US FWS.*

APPENDIX D

STURGEON DATA COLLECTION FORM

REPORTER'S CONTACT INFORMATION
Name: First ________________ Last ________________________
Agency Affiliation ________________ Email______________________
Address ____
____
Area code/Phone number ____

UNIQUE IDENTIFIER (Assigned by NMFS)

DATE REPORTED:
Month ☐☐ Day☐☐ Year 20☐☐
DATE EXAMINED:
Month ☐☐ Day☐☐ Year 20☐☐

SPECIES: (check one)
☐ shortnose sturgeon
☐ Atlantic sturgeon
☐ Unidentified *Acipenser* species
Check "Unidentified" if uncertain .
See reverse side of this form for aid in identification.

LOCATION FOUND: ☐Offshore (Atlantic or Gulf beach) ☐Inshore (bay, river, sound, inlet, etc)
River/Body of Water________________ City________________________ State ____
Descriptive location (be specific)____
____
____
Latitude ______________N (Dec. Degrees) Longitude ______________ W (Dec. Degrees)

CARCASS CONDITION at time examined: (check one)
☐ 1 = Fresh dead
☐ 2 = Moderately decomposed
☐ 3 = Severely decomposed
☐ 4 = Dried carcass
☐ 5 = Skeletal, scutes & cartilage

SEX:
☐ Undetermined
☐ Female ☐ Male
How was sex determined?
☐ Necropsy
☐ Eggs/milt present when pressed
☐ Borescope

MEASUREMENTS: **Circle unit**
Fork length _________ cm / in
Total length _________ cm / in
Length ☐ actual ☐ estimate
Mouth width (inside lips, see reverse side) _________ cm / in
Interorbital width (see reverse side) _________ cm / in
Weight ☐ actual ☐ estimate _________ kg / lb

TAGS PRESENT? Examined for external tags including fin clips? ☐ Yes ☐ No Scanned for PIT tags? ☐ Yes ☐ No

Tag #	Tag Type	Location of tag on carcass

CARCASS DISPOSITION: (check one or more)
☐1 = Left where found
☐2 = Buried
☐3 = Collected for necropsy/salvage
☐4 = Frozen for later examination
☐5 = Other (describe) ________________________

Carcass Necropsied?
☐Yes ☐No
Date Necropsied:____________
Necropsy Lead:
____

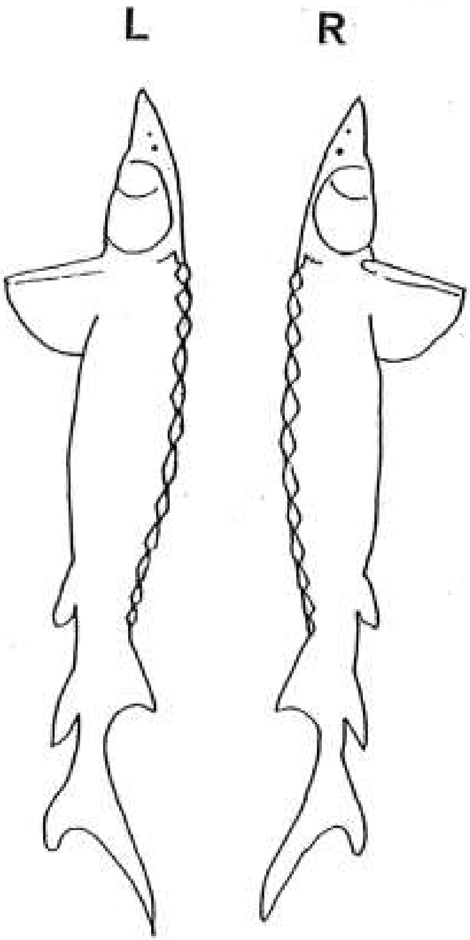
PHOTODOCUMENTATION:
Photos/vide taken? ☐ Yes ☐ No
Disposition of Photos/Video:__________
____
____

SAMPLES COLLECTED? ☐ Yes ☐ No

Sample	How preserved	Disposition (person, affiliation, use)

Comments:

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



Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.).
Please note if no wounds / abnormalities are found.

____

____

____

____

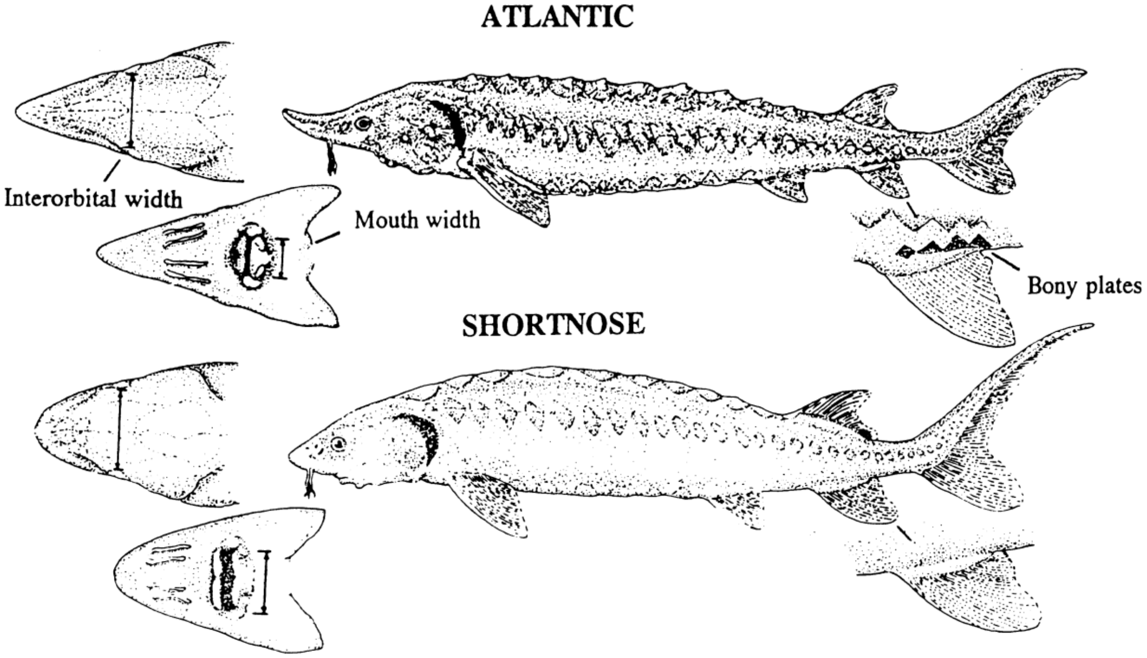
____

Submit completed forms (within 24 hours of observation of fish): by email to
Incidental.Take@noaa.gov or by fax (978-281-9394). Questions can be directed to NMFS Protected Resources Division at 978-281-9328.

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NMFS will notify the collector that these data have been requested and the intent of their use.

APPENDIX E

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



Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

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

* From Vecsei and Peterson, 2004