Appendix F: Ecology

F-6 NMFS Biological Opinion

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

JUN 2 2 2012

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

RE: Transmittal of Biological Opinion– Tappan Zee Bridge Replacement Project

Dear Mr. McDade,

Please find enclosed a copy of the Biological Opinion (Opinion) on the effects of the proposed Tappan Zee Bridge Replacement. In this Opinion, we conclude that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence of endangered shortnose sturgeon, the threatened Gulf of Maine (GOM) Distinct Population Segment (DPS) of Atlantic sturgeon, the endangered New York Bight (NYB) DPS of Atlantic sturgeon or the endangered Chesapeake Bay (CB) DPS of Atlantic sturgeon. We also conclude that the proposed action may affect but is not likely to adversely affect North Atlantic right, humpback or fin whales, the Northwest Atlantic DPS of loggerhead sea turtles, or Kemp's ridley, green or leatherback sea turtles.

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

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

This ITS exempts the following take:

Short Span Bridge Option		
Type of Take	**Shortnose Sturgeon**	**Atlantic Sturgeon**
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	70 (juvenile or adult)	70 total
		64 NYB DPS (juvenile, subadult or adult)
		4 GOM DPS (subadult or adult)
		2 CB DPS (subadult or adult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

Long Span Bridge Option		
Type of Take	**Shortnose Sturgeon**	**Atlantic Sturgeon**
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	43 (juvenile or adult)	43 total
		40 NYB DPS (juvenile, subadult or adult)
		2 GOM DPS (subadult or adult)
		1 CB DPS (subadult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

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

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

Sincerely,

Daniel S. Morris
Acting Regional Administrator

Enclosure

EC: Crocker, F/NER3
Rusanowsky, Chiarella, Boelke - F/NER4
Toni, FHWA
Tomer, ACOE
Knutson, EPA
Kassof, USCG
Wilson, NYDEC

File Code: Sec 7 FHWA Tappan Zee Bridge Replacement
PCTS: F/NER/2012/01752

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
U.S. Environmental Protection Agency, Region II

Activity: **Tappan Zee Bridge Replacement**
F/NER/2012/01780

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

Date Issued: 6·22·12

Approved by:

1.0 INTRODUCTION

This constitutes NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Opinion) issued in accordance with section 7 of the Endangered Species Act of 1973, as amended, on the effects of the proposed Tappan Zee Bridge Replacement Project. The U.S. Federal Highway Administration (FHWA) is the lead agency for the proposed bridge replacement. The U.S. Army Corps of Engineers (ACOE) is proposing to authorize components of the bridge replacement under Section 10 of the Rivers and Harbors Act. The ACOE and the U.S. Environmental Protection Agency (EPA) will authorize the transportation and ocean disposal of dredge material under Section 103 of the Marine Protection, Research and Sanctuaries Act. The U.S. Coast Guard (USCG) will authorize the bridge replacement under the General Bridge Act of 1946.

We are basing this Opinion on information provided in a Biological Assessment (BA) dated January 2012, a revised BA dated April 2012, a Draft Environmental Impact Statement (DEIS) dated January 2012, results of the Pile Installation Demonstration Project (PIDP) provided to us through June 2012 and other sources of available information as cited in this Opinion. A complete administrative record of this consultation will be kept on file at the NMFS Northeast Regional Office, Gloucester, Massachusetts.

2.0 BACKGROUND AND CONSULTATION HISTORY

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

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

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

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

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

We transmitted a draft Opinion to FHWA, the ACOE and the project team on June 14, 2012. We received comments from FHWA, the project team and ACOE on June 18, 2012. All comments received have been addressed as appropriate.

3.0 DESCRIPTION OF THE PROPOSED ACTION

3.1 Federal Actions

FHWA is funding the bridge replacement project and 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. The New York Department of Transportation (NY NYSDOT), the New York State Thruway Authority (NYSTA) and their contractors, will carry out the project. The FHWA is the lead Federal agency for the project for purposes of this ESA consultation and coordination under the National Environmental Policy Act. The USACE and U.S. Environmental Protection Agency (EPA) will authorize the transportation and ocean disposal of dredge material under Section 103 of the Marine Protection, Research and Sanctuaries Act. The US Coast Guard (USCG) will issue a permit under the General Bridge Act of 1946 for construction of the bridge because it crosses navigable waters of the United States.

3.2 Summary of Proposed Action

The proposed project would result in a new bridge crossing of the Hudson River between Rockland and Westchester Counties. A number of design parameters have been considered to develop the location and general configuration of the replacement bridge. Because the project is being progressed as design-build, certain design elements have not yet been finalized, there are options detailed below for some structural characteristics of the bridge.

The replacement bridge would be constructed north of the existing Tappan Zee Bridge. To conform to highway design standards, including widths and grades, there will also be modifications to Interstate 87/287 between approximately Interchange 10 (Route 9W) in Nyack and Interchange 9 (Route 9) in Tarrytown. The location of the proposed bridge is illustrated in Figure 1.

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

Beginning at the abutments, the approaches will carry traffic from land to the main span of the bridge. Construction of the approaches would last for approximately three and a half to four years for the short-span alternative, and two and a half to three years for the long-span alternative. The piles, pile caps, piers, and deck that compose this segment of the bridge would be built sequentially so that as a new pile cluster is being constructed, a completed pile cluster would be undergoing further transformation with, for example, the addition of a pile cap. In water work associated with building the approaches involves pile and cofferdam installation.

The main span would stretch between the Westchester and Rockland approaches and span the federal navigation channel. It is the segment of the bridge that would be defined largely by its superstructure design as an arch or cable stayed bridge. Within its substructure, the piers would be more substantial than those of the approaches. All main span work would be done sequentially and in a similar manner as that of the approaches. The piles, pile caps, pylons, and deck construction would last approximately three and a half years. In water work associated with building the approaches involves pile installation.

Substructure construction would establish the foundation of the bridge through the processes of pile driving, construction of pile caps, and construction of columns. Superstructure construction would then take place either with a gantry that would move from pier to pier lifting segments from barges below (as in the case of the short-span design option) or with a system of winches to lift prefabricated truss sections (as in the case of the long-span option). In the long span option, a short pier-head truss segment would be lifted atop the next open pier column and secured, and then the span truss is lifted to span the gap between the pier head trusses.

Construction of either option for the new bridge would require a wide range of activities on both sides of the river as well as from within the waterway itself. In addition, due to the lack of available land along the waterfront in the vicinity of the bridge, staging areas at some distance from the construction site would be required. Some bridge components would be pre-fabricated and transported to the site via barge.

To support construction of the main span and bridge approaches, materials, equipment, and crews would be transported from upland staging areas in Westchester and Rockland counties to temporary platforms that would be constructed on the shoreline of the river, as shown in Figure

2. Due to the anticipated draft of the work vessels, dredged channels would be required to provide access to the two work areas in the shallow portion of the river crossing: the Rockland and Westchester approaches.

1.4.12

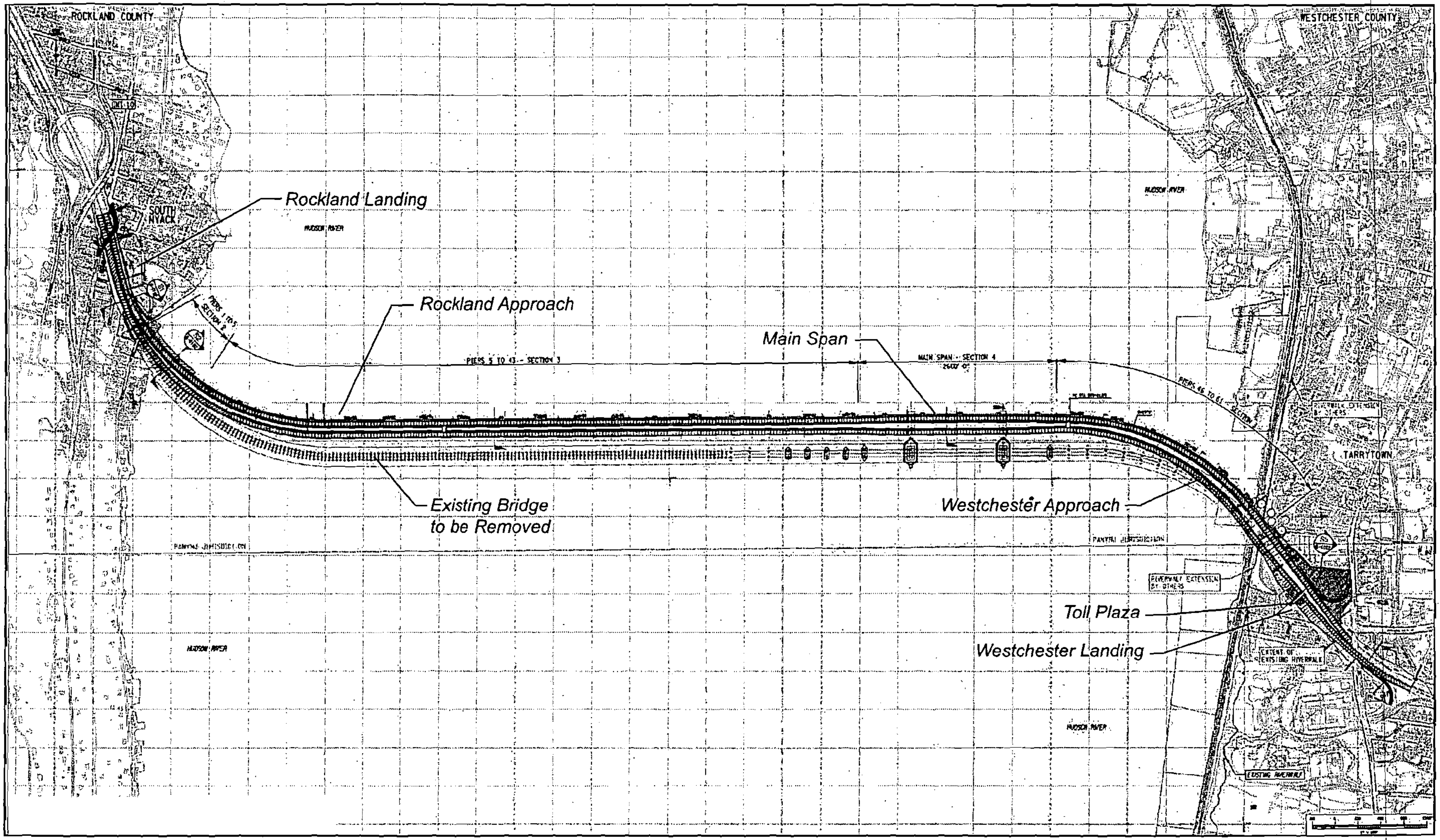


Figure 1
Approach Spans, Main Span, and Ancillary Facilities of the Replacement Bridge

1.5.12

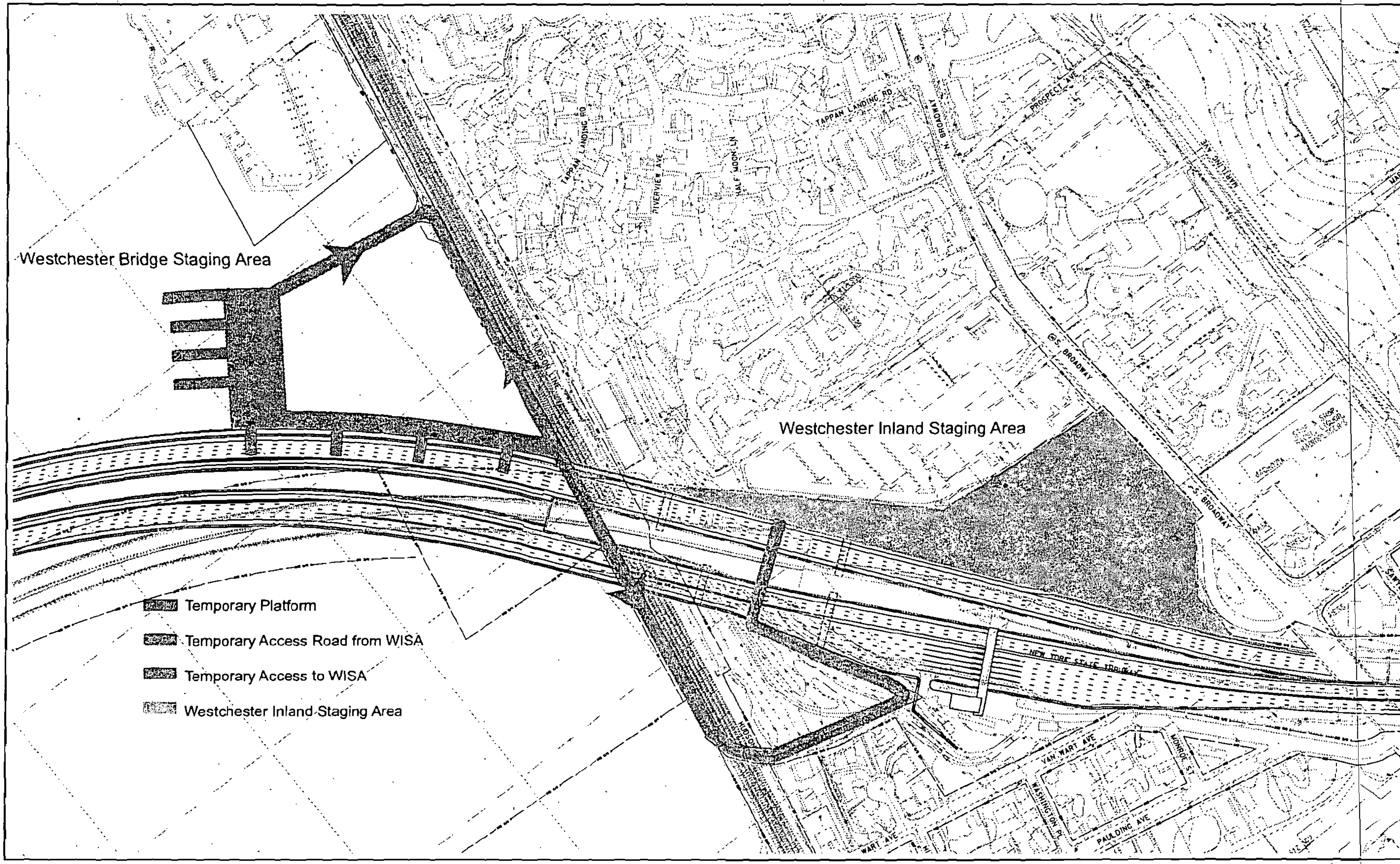


Figure 2
Westchester Landing Construction Access

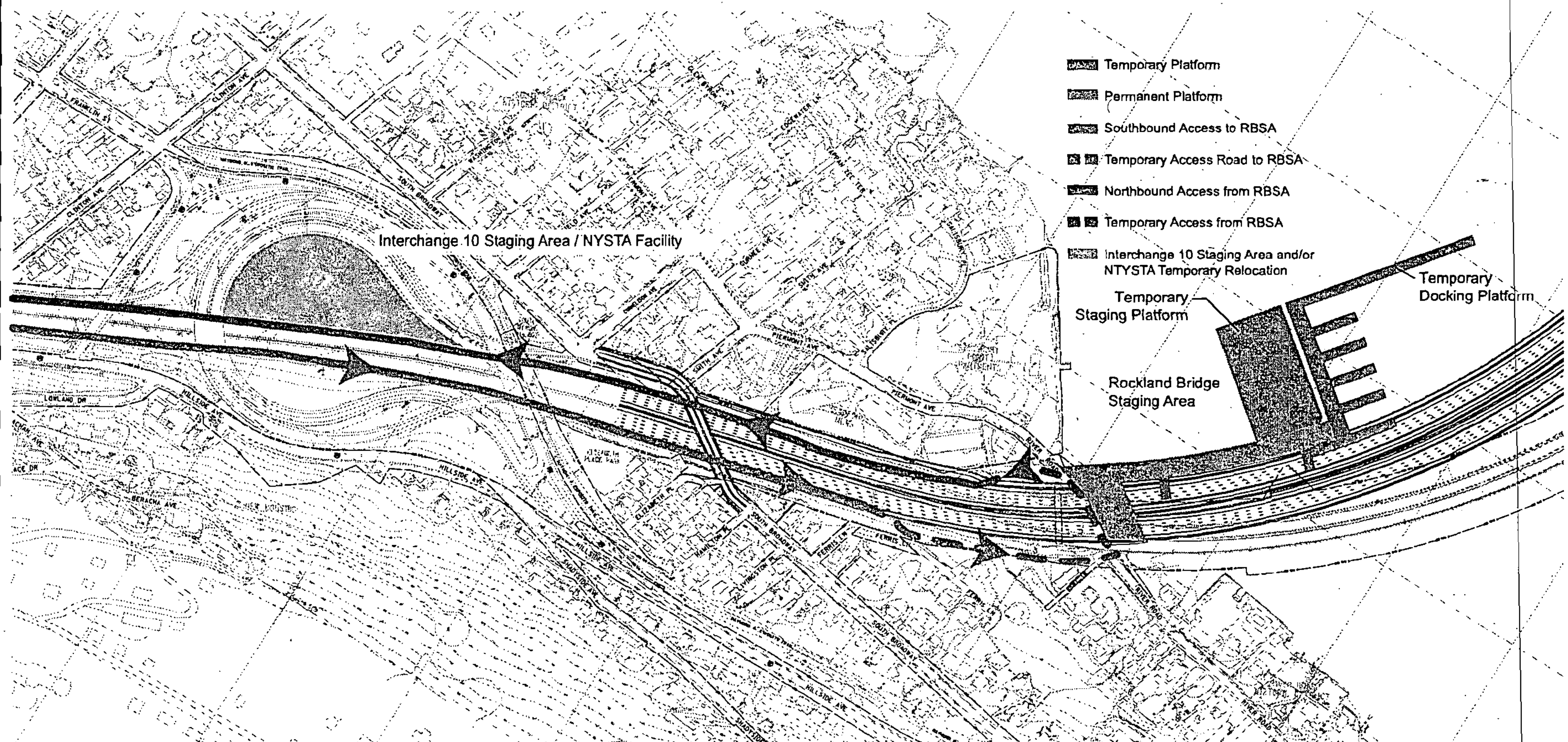


Figure 2

Rockland Landing Construction Access

3.3 Required Environmental Performance Commitments

FHWA will require that certain Environmental Performance Commitments (EPCs) be employed during construction of the substructure. These will become mandatory conditions of any contracts issued for the project and include:

- Driving the largest [3 and 2.4 m (10 and 8 feet)] diameter piles within the first few months of the project thereby limiting the time period of greatest potential impact.

- Using cofferdams and silt curtains, where feasible, to minimize discharge of sediment into the river.

- Using a vibratory pile driver to the extent feasible (i.e., all piles will be vibrated at least to 36.6 m (120 feet) depth or to vibration refusal) particularly for the initial pile segment.

- Using bubble curtain, cofferdams, isolation casings, Gunderboom, or other technologies to achieve a reduction of at least 10 dB of noise attenuation.

- Using the results of the PIDP, which includes the testing of various sound attenuation devices, to inform the project on the effectiveness of BMP technologies for reducing sound levels, and implementing BMPs to achieve maximum sound reduction.

- Limiting the periods of pile driving to no more than 12-hours/day.

- Limiting driving of 8 and 10 foot piles with an impact hammer within Zone C [water depths 5.5-13.7 m (18-45 feet)] to 5 hours per day during the period of spawning migration for shortnose and Atlantic sturgeon (April 1 to August 1).

- Maintaining a corridor where the sound level is below an SEL_{cum} of 187 dB re $1uPa^2 \cdot s$ 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.

- Pile tapping (i.e. a series of minimal energy strikes) for an initial period to cause fish to move from the immediate area.

- Development of a comprehensive monitoring plan. Elements would include:
  - Monitoring water quality parameters such as temperature, salinity, and suspended sediment concentrations 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.
  - 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.
- Preparing a Standard Operating Procedures Manual outlining the monitoring and reporting methods to be implemented during the program.

- In addition, 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 three years of the construction period in which dredging would occur, which would minimize the potential for interaction with the dredge and migration effects to sturgeon and other fish species.

- Armoring of the channel to prevent re-suspension of sediment during the movement of construction vessels, installation and removal of cofferdams, and pile driving.

3.4 Construction of the new bridge

There are two options for the Replacement Bridge's approach spans (Short Span and Long Span Options). As shown in Figure 3, construction of the Short Span Option would take approximately 5½ years. The schedule shows both preliminary activities used to support the construction of the project (i.e., dredging and temporary platforms) as well as individual elements of bridge construction (i.e., main span and approaches). Throughout the construction period roadway work would be required at various times. During that time, the approach roadways would be shifted and remain in the new location for an extended period before being shifted again. The dredging would occur in three stages over the 5 ½ year period, and would be conducted during a three-month window between August 1 and November 1. Construction of the main span would consist of approximately 3½ years of construction. Completion of the short span approaches would involve approximately 3½ to 4 years of construction. Demolition of the existing Tappan Zee Bridge would be expected to span approximately 1 year.

Construction of the Long Span Option would last approximately 4½ years (see Figure 4). The construction sequence and schedule would be similar to that of the Short-Span Option with the exception of the construction of the approaches, which would be expected to take approximately 2½ to 3 years.

1.4.12

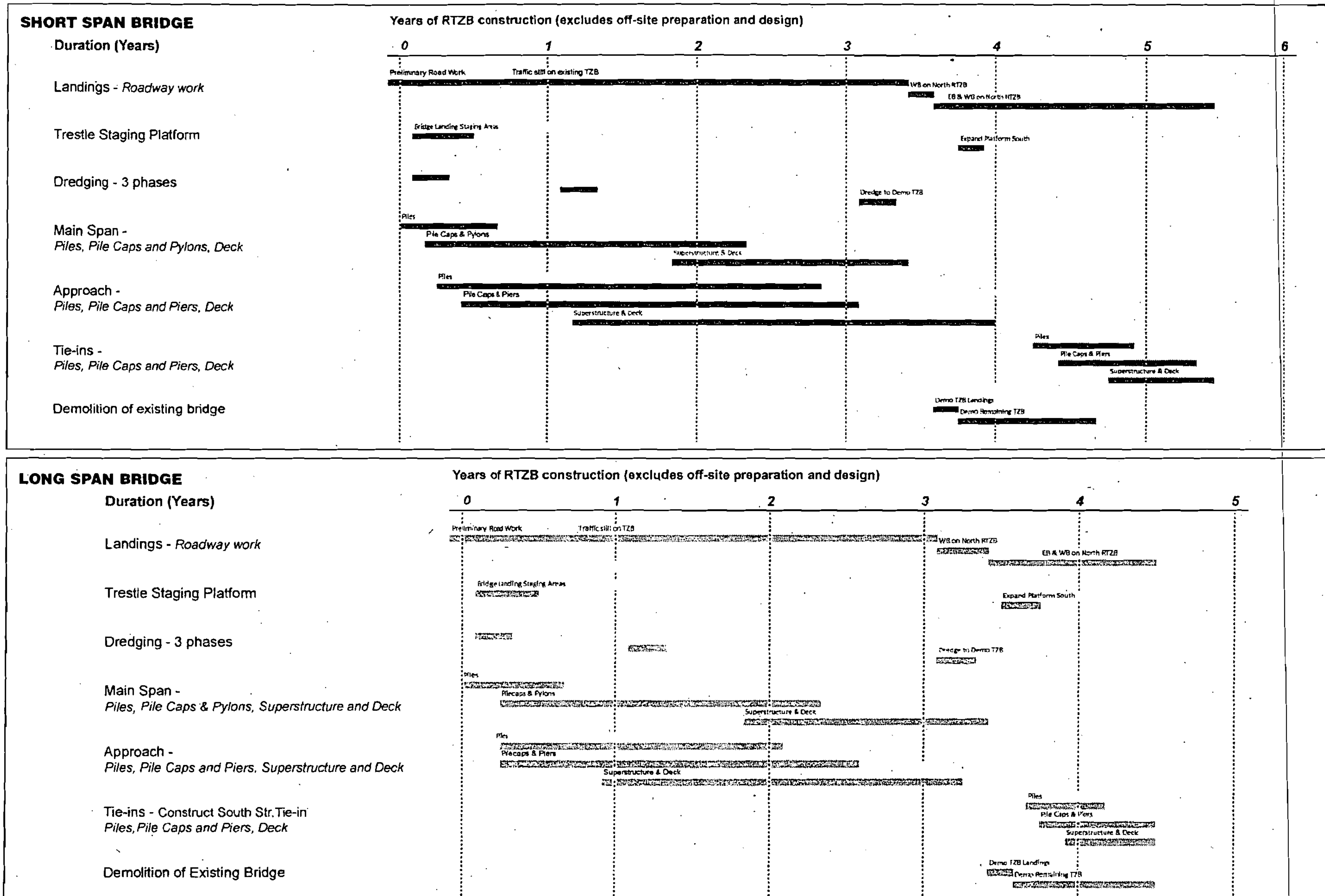


Figure 344

Construction Schedules for Short Span and Long Span Option

3.4.1 Waterfront Construction Staging

The shoreline areas near the proposed bridge site are limited by adjacent development. In order to provide space for the docking of vessels, the transfer of materials and personnel, and the preparation of construction elements, temporary platforms and a permanent platform along the Rockland County side would be extended out from the shoreline over the Hudson River (see Figures 3 and 4). The Rockland platforms would protect the shoreline and also enable the continued maintenance of the original Tappan Zee Bridge as well as providing continued support for the NYSTA Dockside Maintenance facility operation. These platforms would provide access to the replacement bridge site via temporary trestles. Their main purposes would be to facilitate delivery of heavy duty bridge elements from an offsite fabrication facility, receive deliveries from the concrete batch plant, receive deliveries (i.e., construction equipment and light duty bridge elements) from the staging areas, and allow for barge-mounted cranes to erect heavy duty bridge elements. Upon completion of construction, the temporary platforms and the piles that support them would be removed.

As the construction of the temporary platforms and access trestles would begin at the shoreline, an access road and work area near the shore would also be constructed. A channel would be dredged specifically to provide tug boat and barge access to the temporary platforms from in-river work sites.

3.4.2 Dredged Access Channel

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

As shown in Figure 5, dredging would be conducted in three stages between August 1 and November 1 over a 4-year period. An environmental bucket dredge will be used with no barge overflow allowed. The purpose of the first two dredging stages (Years 1 and 2) would be to provide access for bridge construction, while the final dredging stage (Year 4) would provide access for demolition of portions of the existing bridge allowing for completion of the remaining portions of the new structure.

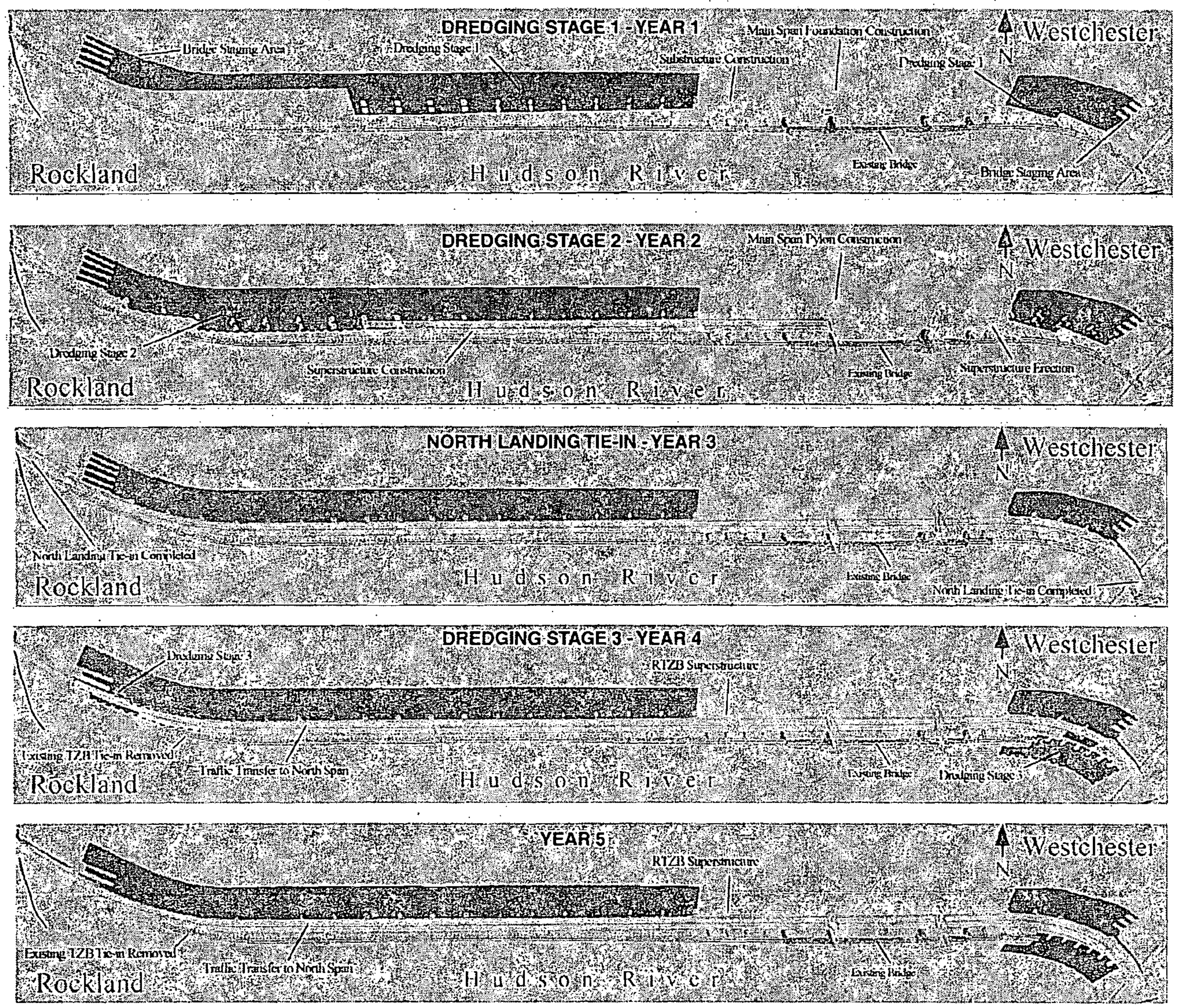
Based on an analysis of the types, number, size and operation of vessels that would operate in the access channel during construction, it was determined that a clear draft of at least 3.6 m (12 feet) would be required within the access channel. To avoid the potential for grounding of vessels, an additional two feet would be added to provide a working channel depth of 4.3 m (14 feet) at the lowest observed water level, which occurs during the Spring Neap Tide. The lowest observed water level is referred to as Mean Low Low Water (MLLW).

Table 1 shows the amount of material to be dredged during each stage for the two bridge design options. For either design option, the channel width would measure approximately 145 to 161 m (475 to 530 feet), and it would extend approximately 2,133 m (7,000 feet) from the Rockland County side into deeper waters and 610 m (2,000) feet from the Tarrytown access trestle into deeper waters. Because the long span alternative would occupy a wider footprint, a slightly larger area must be dredged for that alternative. It is estimated that approximately 1.28 and 1.33 million cubic meters (1.68 and 1.74 million cubic yards) of sediment would be dredged for the short and long span options, respectively.

Table 1. Dredging Quantities for the Replacement Bridge Alternatives

Construction Stage	**Short Span**		**Long Span**	
	Quantity (million CY)	**Percent of Total**	**Quantity (million CY)**	**Percent of Total**
Stage 1	1.08	64%	1.12	64%
Stage 2	0.42	25%	0.43	25%
Stage 3	0.18	11%	0.19	11%
Total	1.68	100%	1.74	100%

Notes:
CY = cubic yards
Dredging for bridge demolition (Stage 3) includes that portion of the bridge which must be removed to complete the Replacement Bridge Alternative tie-in.



Note: Long Span Option is depicted, Short Span Option will be similar

Figure 5
Dredging Sequence, Years 1 to 5

3.4.3 Armoring of River Bottom in Dredged Access Channel

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

The installation of the sand and gravel would take place as soon as the dredging for that section of the channel was successfully completed, forming a protective layer to keep sediment from further disturbance. The sand and gravel materials would be delivered by barges or scows, and would be placed within the channel by barge-mounted cranes. The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. The dredging depth required assumes that two feet of sand and gravel armor is placed on the bottom. In total, the channel would be dredged to a depth corresponding to 4.9 m (16 feet) below MLLW to allow for the required 14 ft of clear draft and 2 ft of armoring.

3.4.4 Transport and Disposal of Dredged Material

During each three-month period when dredging is occurring, dredged materials would be collected from the bottom of the river by barge-mounted cranes and placed into hopper scows, which have a capacity of approximately 1,911 cubic meters (2,500 cubic yards). To ensure that the scows do not exceed the maximum allowable draft of the river work zone, they would be limited to 80 percent of their maximum load, or 1,529 cubic meters (2,000 cubic yards) per load.

Each dredging stage would occur during a 90-day period. During that period, it is estimated that dredging would occur up to 75 of the 90 days, with two dredges operating at a time. During the busiest dredging stage, Stage 1, up to 11,468 cubic meters (15,000 cubic yards) of materials would be dredged each day. Table 2 presents the estimated daily volumes of materials removed for each dredging stage for the two replacement bridge alternatives.

Construction Stage	**Short Span Daily Volume (cubic yards)**	**Long Span Daily Volume (cubic yards)**
Stage 1	14,600	15,000
Stage 2	5,700	5,800
Stage 3	2,400	2,600

Table 2. Daily Materials Removal by Construction Stage

After placement in the hopper scows, the next step in the dredge materials handling would depend on the dredge placement option selected.

Certain activities related to the project are left to the discretion of the contractor. One of these would be the ultimate transport and disposal of dredge spoils from construction of the access channel. FHWA has identified two likely options for dredge disposal; use of the HARS site or at an upland site. Both options are described below. FHWA believes that it is most likely that the contractor will use the HARS rather than an upland disposal site based on cost, schedule, logistics and the avoidance of impacts to the surrounding residential communities on the Rockland and/or Westchester shorelines.

3.4.4.1 Use of the HARS

The HARS is located 5.6 km (3.5 miles) east of Sandy Hook, NJ (see Figure 6). The HARS is overseen by the USACE and the U.S. EPA. This site was historically used for ocean disposal of dredged material and a variety of waste products, including some contaminated materials. Today, the site is being remediated through a program to cap those historic sediments with cleaner sediments dredged from Mid-Atlantic waters, primarily New York Harbor, which meet certain criteria established by the Ocean Dumping Act.

Disposal at HARS requires a permit from the USACE. To receive the permit, materials must be suitable for remediation, in that they meet certain criteria related to contaminants based on sediment toxicity and bioaccumulation tests. In addition, in accordance with 40 CFR §227.16, the EPA must evaluate alternative disposal options before permitting placement of dredged material at the HARS, and must find that there are no practicable alternative locations and methods of disposal or recycling available. FHWA has prepared documentation outlining their determination that there are no practicable alternatives locations for the placement of the dredged material at the HARS site.

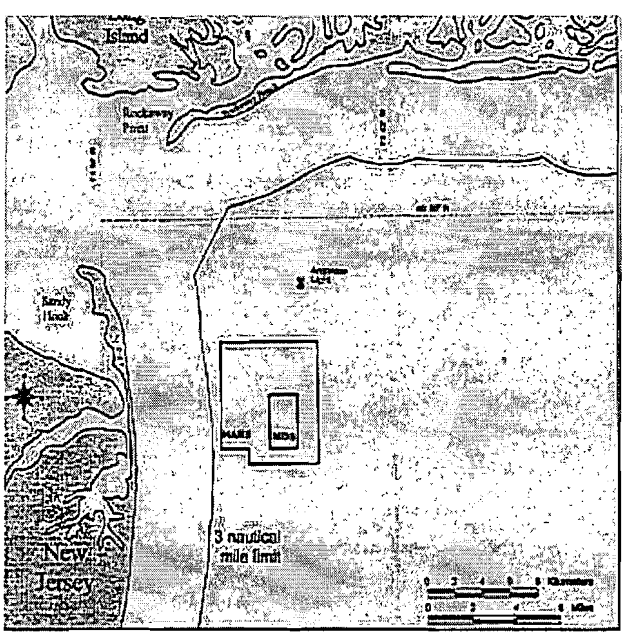


Figure 6. Location of the HARS dredge disposal site.

FHWA is proceeding with sampling and analysis of the dredged material in support of the application for a permit under Section 103 of the Marine, Protection, Research, and Sanctuaries Act of 1972. If approved, the dredged materials from the Tappan Zee Hudson River Crossing Project placed at the HARS would be transferred from the hopper scows to larger capacity [up to 3,440 cubic meters (4,500 cubic yards)] ocean scows. These vessels have large drafts, typically up to 5.5 m (18 feet), which would be too large to be accommodated in the dredged construction channel. Therefore, materials would be transferred from the hopper scows to the ocean scows in deeper water areas of the Hudson River. The ocean scows would then travel to the HARS, where materials would be placed at the site in accordance with the permit conditions for that placement.

3.4.4.2 Upland Disposal

If the permit application for the use of HARS is denied in whole or part, the contractor would be required to dispose of the dredged material at an approved facility in accordance with all applicable laws and regulations. Dredged material would be transferred directly to a truck or to a barge and then to a truck or rail, for ultimate disposal at a permitted upland facility.

3.4.5 Substructure Construction

Substructure construction would vary as a function of water depth and sediment conditions at each location. Work on the foundations can be categorized into three segments referred to as Zone A, Zone B, and Zone C (see Figures 7 and 8). Pile installation would typically be performed one row of piles at a time. The actual pile driving is done one pile at a time. As shown in Table 3, a total of 1,326 piles for Piers 1 to 57 would be required for the Short Span Option. Table 4 includes similar information for the Long Span Option at Piers 1 thru 32. The Long Span Option would require 836 piles. In terms of the largest piles, the number of the 3-m (10-foot) piles would be the same (50) for either option. The greatest difference between the two options would be the number of smaller 1.2-m (4-foot) piles with the Short Span Option requiring approximately 346 more piles than the Long Span Option. The Long Span Option would also require 104 less 1.8-m (6-foot) piles and 40 less 2.4-m (8-foot) piles for a total difference of 490 piles. Under either option, the driving of the largest piles [2.4- and 3-m) (8- and 10-foot)] would only occur for a few months in the first year of construction.

Table 3. Pile Driving, Short Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-3	A1	6	4	24
4-8	B1	6	6	60
9 – 14	B1	4	20	240
15-32	B1	4	20	720
33-35	B1	8	4	24
36-43	C	8	4	64
44-45	C	10	25	50
46-50	C	6	6	60
51-57	B2	6	6	84
Total				**1,326**

Table 4. Pile Driving, Long Span Option

Pier No.	Substructure Zone	Pile Size (diameter ft)	No. of Piles Within each Pier	Total No. of Piles
1-2	A1	6	4	16
3	A1	6	6	12
4	B1	6	6	12
5-17	B1	4	25	614
18-21	B1	8	4	32
22-23	C	8	4	16
24-25	C	10	25	50
26-28	C	6	6	36
29-30	B2	6	6	24
31-32	A2	6	6	24
Total				**836**

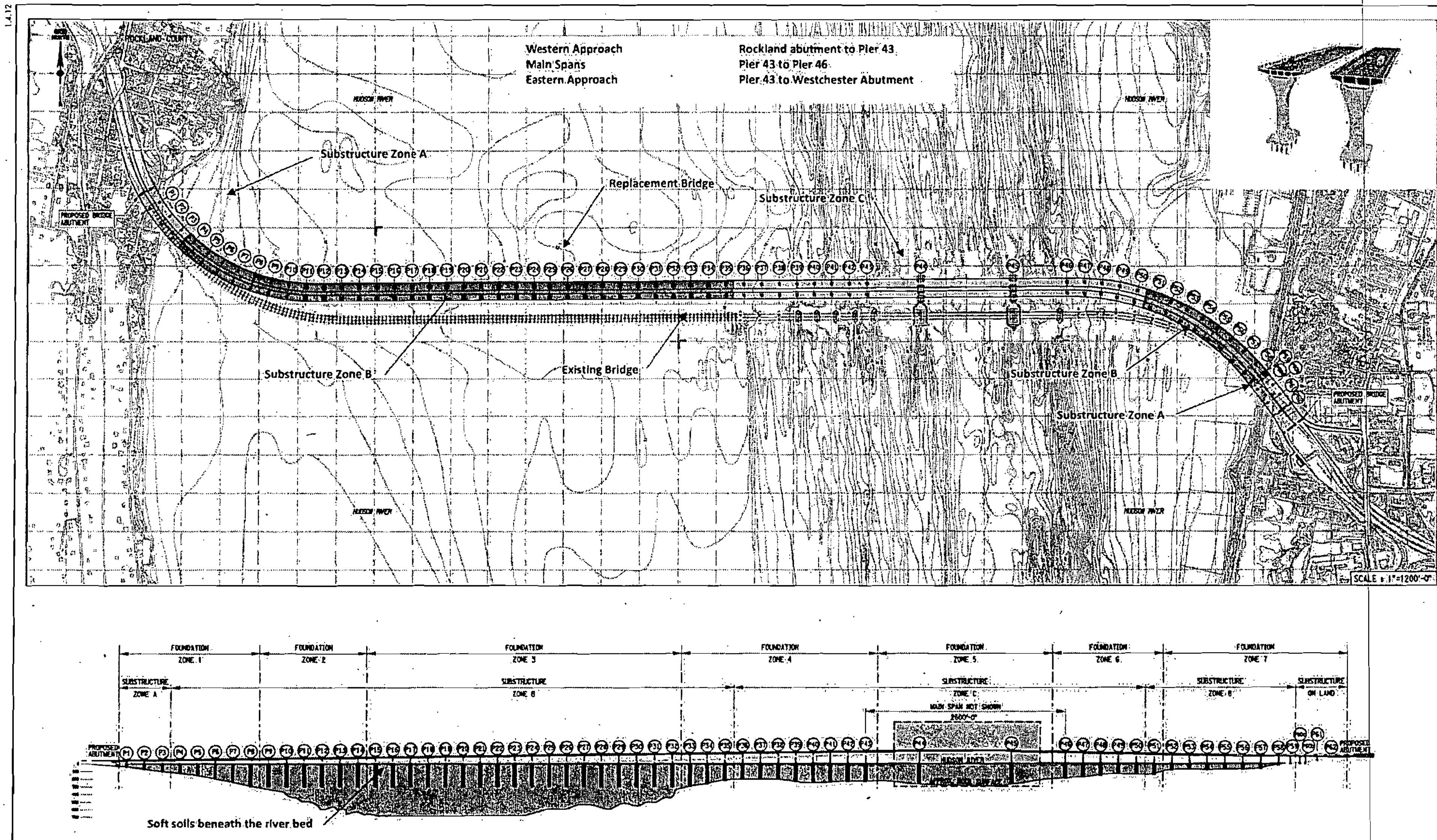


Figure 7
Construction Zones for Short Span Option

1.4.12

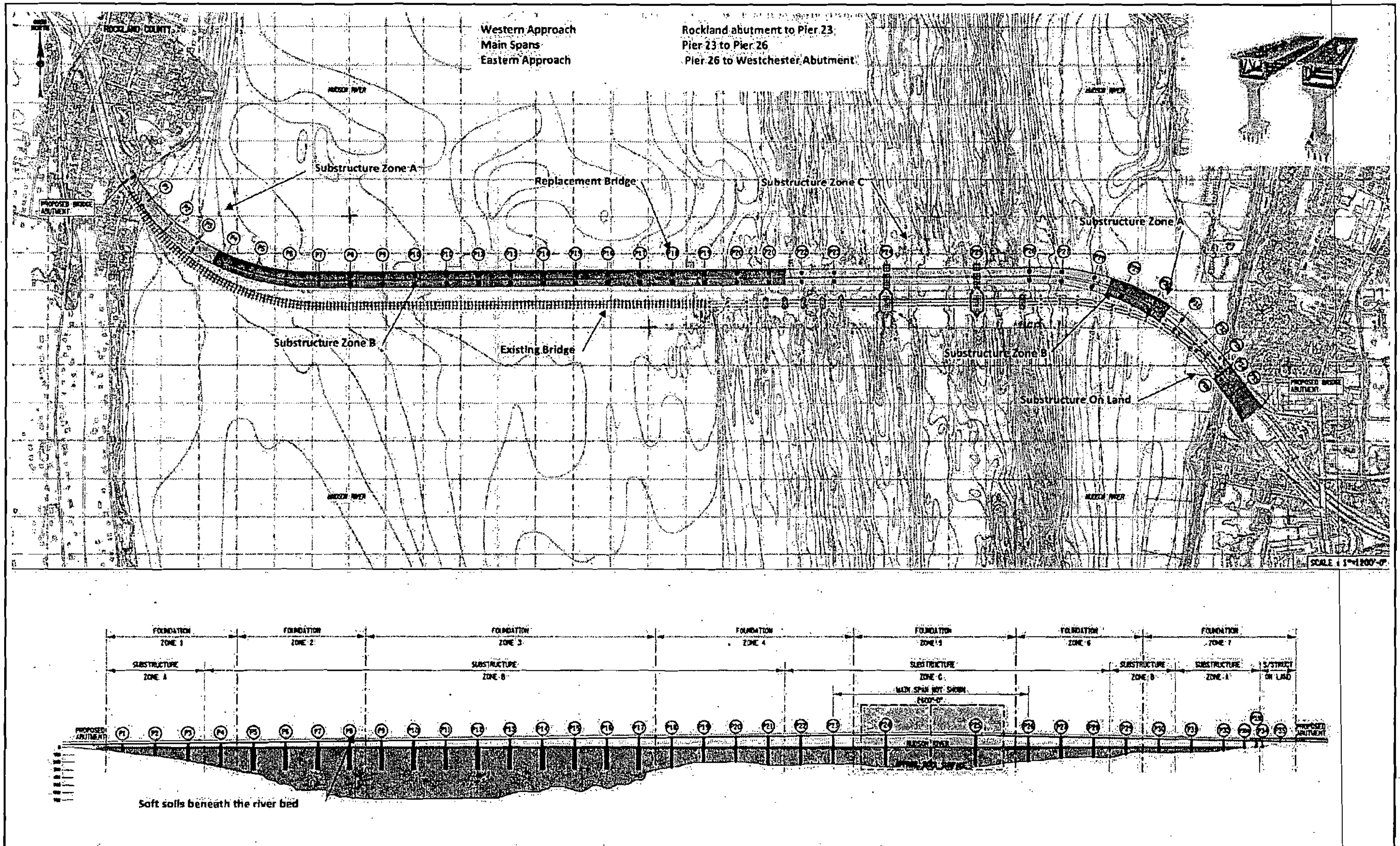


Figure 8
Construction Zones for Long Span Option

3.4.5.1 Foundation Zone A

The two areas of shallowest water depth extend from the shorelines on the Rockland and Westchester sides of the Hudson. These areas, where the water measures less than 2.1 m (7 feet) in depth, are labeled as Zone A. The area adjacent to the Rockland shoreline is labeled Zone A1, while the area adjacent to the Westchester shoreline is Zone A2. Zone A substructure elements would be constructed within cofferdams from adjacent temporary trestle platforms. These cofferdams would be constructed prior to pile driving the bridge foundation piles. The cofferdam would remain flooded during pile installation but would be dewatered prior to installation of the pile caps.

3.4.5.1.1 Cofferdams

A cofferdam is a watertight chamber designed to facilitate construction in an area that would otherwise be underwater. In this case, the cofferdams would be composed of interlocking sheet piles extending into the riverbed a distance of up to 6.1 m (20 feet). Cofferdams will be vibrated in place which will also act to minimize hydroacoustic effects. Upon completion of the cofferdam, foundation piles would be driven into the riverbed.

3.4.5.1.2 Pile installation

A 300-ton crawler crane would suspend the 45.7-m (150-foot) pile sections and support the pile driving hammer during operation. Prior to pile driving, a template to guide piles would be placed within the cofferdam to ensure that they are in position and to hold them when pile driving is not taking place. A quick, low-noise, moderate-energy vibratory hammer would be used to install much of the length of the pile, after which a high efficiency hydraulic impact hammer suspended from cranes operating on the two temporary shoreline access trestles would be used to apply force to the tops of the piles so as to deliver the piles more deeply into the riverbed. The use of vibratory hammers for the entire driving operation is not possible due to the excessive depths to bedrock. Once all piles are driven, the template and its supports would be transitioned to the next cofferdam.

3.4.5.1.3 Pile caps

Upon completion of pile installation, a tremie seal, which braces the bottom of the sheet pile cofferdam and provides a seal at the base of the cofferdam to allow for dewatering of the cofferdam, would be poured and the cofferdam would be dewatered. River water recovered during dewatering of the cofferdams would be routed to tanks to settle out any suspended sediments (or a water filtration system as necessary) and discharged back to the Hudson River in accordance with conditions issued by the NYSDEC under the Section 401 water quality certification for the project. As NYSDEC is requiring a 24 hour settling period for discharge of barge decant water, it is expected that this would be a maximum settling period requirement for river water recovered during dewatering of the cofferdams.

After dewatering of the cofferdam, the interior of the piles would be excavated and a tremie concrete plug would be poured into the hollowed pile to prevent water infiltration. The pile itself would be dewatered down to the plug, reinforcing steel installed, and the pile would be filled with concrete. Prior to the installation of the pile cap, pier reinforcement, post tensioning ducts, and pile reinforcement would be secured. A pile cap, which is a reinforced concrete slab constructed atop a cluster of foundations piles, would then be constructed to form a single structural element that would allow for even distribution of the weight that the piles bear, avoiding over stressing any individual component. These slabs would also provide a larger area for the construction of the columns that they will support.

3.4.5.2 Foundation Zone B

The water depths in Zone B range from 1.5 to 5.5 m (5 to 18 feet), and the zone is characterized by a relatively deep soft-soil profile. Zones B1 (close to the Rockland shoreline) and B2 (close to the Westchester shoreline) are located adjacent to Zones A1 and A2 and are closer to the centerline of the river. Work performed for substructure construction in Zone B would take place in cofferdams, but would be completed from barges and support vessels.

3.4.5.2.1 Pile Installation

Piles, which would be transported in two pieces to Zone B by barge, would measure between 76.2 and 91.4 m (250 and 300 feet). Pile driving would begin immediately upon completion of the cofferdam construction. A 300-ton crawler crane would lift the pile sections. A pile-driving rig would supply a hammer suspended from the barge mounted crane. The template would be positioned to guide the lower pile section into proper position before the pile would be allowed to delve into the soft stratum under its own weight. The depth achieved in this manner would be considerable, and should the application of further pressure be called for, a vibratory hammer would be used to drive the remainder of the pile into place. Upon the placement of the lower segment of the pile, preparations to begin welding the two segments together will commence. In order for the two segments to be joined, the upper segment would be hovered over the lower until the automated welding process was complete. Upon the completion and inspection of the welding, the remaining length of the conjoined pile would be driven to required depth or specified penetration resistance with a hydraulic hammer. The soil within the pile would be excavated to a depth of approximately 120 ft and transported to an off-site disposal facility in order to create space for the tremie plug, steel reinforcing cage and concrete pour. Cofferdams will be dewatered following the installation of the piles.

3.4.5.2.2 Pile caps

The construction process of pile caps in Zone B would be similar to that of Zone A. One difference would be that a granular fill material would be distributed inside of the cofferdam to enable the tremie seal to be poured to its planned elevation prior to dewatering. This granular material would remain after the removal of the cofferdam.

3.4.5.3 Foundation Zone C

Foundation Zone C lies between Zones B1 and B2, connecting the two approaches from both sides of the river. This zone is defined by the greatest water depths, which range from 5.5 to 13.7 m (18 to 45 feet). Construction in this zone would encompass the construction of the main span as well as that of both approaches.

The first substructure construction activity in Zone C would be the installation of the foundation piles. In this zone, due to the greater depths than Zones A or B, cofferdam construction would follow the pile installation, thus requiring that the cofferdam be constructed around the installed pile to create a dry environment in which to construct the tremie seal. The cofferdam in Zone C would be constructed using a different method than that utilized in Zones A and B. This alternative method, the "hanging cofferdam method", would begin with the installation of a temporary support structure above the foundation piles on which the cofferdam would be assembled. The cofferdam components would then be pieced together and suspended from the support structure. Once the hanging cofferdam is assembled it is lowered over the pile cluster. No pile driving will be needed for installation of the hanging cofferdams in zone C. After the placement of the cofferdam, divers would seal the gaps between the cofferdam floor and the piles, then the tremie slab would be poured onto the cofferdam floor to seal the cofferdam for dewatering and pile cap construction.

3.4.5.4 Construction of Bridge Superstructure

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

3.5 Existing Bridge Demolition

The existing Tappan Zee Bridge contains five segments: causeway, east trestle, east deck truss, west deck truss, and main spans. The demolition of the existing bridge will be performed in two stages. The first stage will include partial demolition to allow for construction of the new bridge, and the second stage will occur after the completion of the new bridge. No blasting or underwater detonations for removal of the existing structure would occur.

3.5.1 Causeway and East Trestle Spans

The causeway is a simple span construction composed of 166 spans measuring 15.2 m (50 feet), with the exception of one 30.5-m (100-foot) span. The east trestle is comprised of six spans. Within its simple span construction, the causeway contains a stringer and deck superstructure and a substructure of concrete columns and footings on timber piles. Initially, the deck and stringers would be lifted out and placed onto awaiting barges. Then, the protective dolphins would be cut so as to offer unrestricted access for pier removal. Columns and footings would either be cut with diamond wire or broken by pneumatic hammers. Finally, the timber piles forming the causeway foundation would be cut to just below the mud line. All materials would be transported to an appropriate permitted off-site disposal facility, and a turbidity curtain would be utilized to ensure that demolition debris would not be dispersed. Side-scan sonar surveys would be performed in order to verify that all generated debris would be removed from the river. Debris will be removed with crane/bucket if necessary.

3.5.2 Deck Truss Spans

The deck truss spans, including 13 east deck, 7 west deck, and all approach truss spans, each contain a deck slab, steel trusses, and concrete piers supported on buoyant foundations or caissons. The deck slabs would be removed and transported off-site by an awaiting barge. A channel would then be dredged in Stage 3 (see above) to provide access to the trusses near the Westchester shoreline, and steelwork would either be removed by barge-mounted crane or a crane mounted on an adjacent in-tact span. Caisson-supported piers would be demolished using the same process as in the causeway and east trestle spans, and would then be removed just below the mud line through excavation and using diamond cutting wire devices or pneumatic hammers. Steel H piles would remain below the mud line. Turbidity curtains surrounding areas where in-water work was ongoing and netting to contain debris would also be used in this stage.

3.5.3 Main Span

The main span stretches 735.2 m (2,412 feet) and is structurally formed by a through truss above a deck supported by four latticework piers on buoyant foundations, ice deflectors around the two central piers, and pre-stressed concrete beams on 76 cm (30-inch) diameter steel piles. Initially, the main span deck slab panels would be lifted and removed off-site by barge. Then, the entire suspended span would be lowered onto a barge via a strand jack or winch system. Conventional barge-mounted cranes would then deconstruct the anchor span steelwork piece by piece and the ice-breaker and fender structures protecting the main span piers would be demolished by divers and barge-mounted cranes. The pier steelwork would also be removed piece by piece, and the buoyant caissons would be flooded, cut and removed in pieces. Following main span demolition, a barge-mounted crane operated clam shell bucket would clear the river bottom of debris. Side-scan sonar surveys would verify that all debris and concrete were removed from the river.

3.6 Action Area

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area includes the project footprint where work to construct the new bridge and remove the old bridge will take place, including dredging and armoring of the river bottom. The action area also includes the area of the river where increased underwater noise levels and changes in water quality will be experienced. The action area also includes the likely dredge disposal site (HARS) and the transit route that barges will use to access the site. The HARS is located approximately 4 miles (3.4 nautical miles) east of Highlands, New Jersey and about 9 miles south of Rockaway, Long Island. It comprises about 20 square miles within the apex of the New York Bight[1] that includes the approximately 3-square-mile Mud Dump Site (MDS). We anticipate that all effects of the action will occur within this geographic area. See Figure 1 for a map of the bridge location. Figure 6 is a map of the HARS site.

[1] The New York Bight is a region defined as ranging from Cape Cod, MA, to Cape May, NJ, and includes Buzzard's Bay, Long Island Sound, New York Harbor and the New Jersey shore (http://web2.uconn.edu/seagrantnybight/).

4.0 SPECIES THAT ARE NOT LIKELY TO BE ADVERSELY AFFECTED BY THE PROPOSED ACTION

Sei (*Balaenoptera borealis*) whales occur in deep water throughout their range, typically over the continental slope or in basins situated between banks (NMFS 2011). Sperm whales (*Physter macrocephalus*) occur on the continental shelf edge, over the continental slope, and into mid-ocean regions. Sei and sperm whales do not occur in the action area.

We have determined that while the following species may be present in the action area, the actions being considered in the Opinion are not likely to adversely affect the following species: leatherback (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys kempi*) and green (*Chelonia mydas*) sea turtles; the Northwest Atlantic DPS of loggerhead sea turtle (*Caretta caretta*); North Atlantic right whales (*Eubalaena glacialis*), humpback whales (*Megaptera novaeangliae*), and fin whales (*Balaenoptera physalus*). All of these species are listed as threatened or endangered species under the ESA. Below, we present our rationale for this determination.

4.1 Presence of Whales and Sea Turtles in the Action Area

The large whales and sea turtles noted above do not occur in the Hudson River and therefore would not be exposed to any effects of bridge construction. However, these species may be present at the HARS site or along portions of the vessel transit route. Here, we consider effects to these species.

Right, fin and humpback whales are seasonally present off the coast of New York and New Jersey but are typically found in deep offshore waters. Sightings and satellite tracking data along the east coast indicate that endangered large whales rarely venture into bays, harbors, or inlets (70 FR 35849, June 25, 2005, NMFS 2007, 72 FR 57104, October 5, 2007). As such, we do not expect that any of these species would be present along the transit route through New York Harbor. However, given the HARS offshore location, these whale species may be present at the disposal site and along the offshore portion of the transit route. Right whales are most likely to occur in this area from November – April; humpback whales are most likely to be present in the spring, summer and fall. Acoustic monitoring data from coastal New Jersey indicates that individuals from all three of these whale species may occur in the coastal waters off New York and New Jersey throughout the year (NJDEP 2010). The project will use the HARS site for dredged material disposal between August 1 and November 1; right, humpback and fin whales could be present at the site or along the transit route during this time of year. Whales in this area are expected to be migrating and may also be foraging if suitable forage is present.

Sea turtles are seasonally present in waters off the coast of New York and New Jersey. Sea turtles arrive in the mid-Atlantic from southern overwintering area in May and typically begin migrating southward by mid-November. Satellite tracking studies of sea turtles in New York waters found that foraging turtles mainly occurred in areas where the water depth was between approximately 16 and 49 feet (Ruben and Morreale 1999). This depth was interpreted not to be as much an upper physiological depth limit for turtles, as a natural limiting depth where light and food are most suitable for foraging turtles (Morreale and Standora 1990). Depths at the HARS site range from 46-138 feet. We expect sea turtles to be present at the HARS site between May and November, with the highest number of individuals present between June and October. Sea turtles in this area are likely to be migrating or foraging.

For the species of whales and sea turtles that may occur at the HARS site and along portions of the transit route, we have considered effects of disposal activities (see section 4.2) and effects of vessel operations (see section 4.3) and have determined that all effects will be insignificant and discountable. The rationale for our determination is presented in Section 4.2 and Section 4.3 below.

4.2 Effects of disposal of dredged material at HARS on whales and sea turtles

Potential effects of dredged material disposal include: (1) increased turbidity; (2) exposure to contaminants; and, (3) impacts to benthic resources.

4.2.1 Turbidity

During the discharge of sediment at a disposal site, suspended sediment levels have been reported as high as 500.0 mg/l within 250 feet of the disposal vessel and decreasing to background levels (i.e., 15.0-100.0 mg/l depending on location and sea conditions) within 1,000-6,500 feet (ACOE 1983). In the BA, FHWA indicates that at the HARS, total suspended solids near the center of the dredged material placement plume body have been observed to reach near background levels in 35 to 45 minutes (Battele 1994 in USACE and USEPA 2009).

TSS is most likely to affect sea turtles or whales if a plume causes a barrier to normal behaviors or if sediment settles on the bottom and affects benthic prey. As whales and sea turtles are both highly mobile, individuals are likely to be able to avoid any sediment plume that is present and any effect on their movements or behavior is likely to be insignificant.

Right whales feed on copepods (Horwood 2002; Kenney 2002). Humpback and fin whales feed on krill as well as small schooling fish (*e.g.*, sand lance, herring, and mackerel) (Aguilar 2002; Clapham 2002). Leatherback sea turtles feed on jellyfish. Green sea turtles feed on sea grasses and macroalgae. Loggerhead turtles feed on benthic invertebrates such as gastropods, mollusks and crustaceans. Kemp's ridleys primarily feed on crabs, with a preference for portunid crabs including blue crabs.

The TSS levels expected (up to 500 mg/L) are below those shown to have an adverse effect on fish (580.0 mg/L for the most sensitive species, with 1,000 mg/L more typical; see summary of scientific literature in Burton 1993) and benthic communities (590.0 mg/L (EPA 1986)); therefore, effects to whale and sea turtle prey from increased turbidity is extremely unlikely; effects to listed whales and sea turtles will be discountable.

4.2.2 Effects to the Benthic Environment

Disposal operations can also affect foraging animals by burying benthic prey. Direct impacts to fish or other mobile species during placement of the dredged material at the HARS would be expected to be minimal due to the small contact footprint of the fluidized sediments as they leave the barge (typically 50 foot by 100 foot). Given the small area impacted by each disposal event, mobile species are expected to be able to avoid the falling sediment and would not be subject to burial. The only species that are likely to be buried are immobile benthic organisms. Sea grasses and macroalgae that green sea turtles forage on are not present at the HARS. The species that whales and leatherback sea turtles forage on are mobile and not likely to be vulnerable to burial. Some species of mollusks and gastropods that loggerheads feed on have limited mobility and could be buried during disposal operations.

The loss of potential benthic prey species would be minimized spatially and temporally through use of a grid system for the placement of dredged material. Some buried animals will be able to unbury themselves. Areas where dredged material will be placed are expected to be recolonized by individuals from nearby similar habitats. Because the characteristics of the sediment from the project would be similar to those in and around the HARS, benthic invertebrates would be expected to quickly recolonize the cells used for the placement of this material. Thus, any reduction in benthic prey at the HARS site will be temporary and limited to the small area where dredged material will be placed. Right, humpback and fin whales and green, Kemp's ridley and leatherback sea turtles will not have any reduction in prey. The potential loss of prey for loggerhead sea turtles will be extremely small, as only a fraction of the benthic species that loggerheads prey on will be affected, and those losses will occur in a very small area. Effects to foraging loggerhead sea turtles will be insignificant.

4.2.3 Contaminants

In order to be eligible for ocean disposal, material must meet stringent criteria as required by the Clean Water Act and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (as described in the EPA/ACOE joint testing guidelines, available at http://water.epa.gov/type/oceb/oceandumping/dredgedmaterial/upload/gbook.pdf; last accessed May 10, 2012). By law and regulation, the significant adverse effects of dredged material disposal activities must be contained within the designated or selected disposal site and even those impacts must not degrade the area's overall ecological health. The HARS is required to have and is managed under a dredged material monitoring and management plan that assesses the health and well-being of the site and surrounding environment. Monitoring of the disposal site is a part of this plan, which is designed to ensure that any degradation of resources or alteration in seafloor characteristics are identified and results in actions by permitting agencies (USEPA 2004).

The testing of dredged material is overseen by EPA and the ACOE. Sediments are tested for possible contamination prior to any planned dredging to ensure that proposed dredging and the dredge material disposal are conducted in a way that minimizes the potential pathways for contaminant exposure. EPA and the ACOE have jointly developed comprehensive testing procedures, which may include physical, chemical and biological tests, to evaluate dredged material placed into ocean waters. Additional, more stringent criteria apply to material disposed of at the HARS.

Laboratory and evaluation methods that apply to dredged material proposed for ocean disposal in accordance with the Marine Protection, Research and Sanctuaries Act (MPRSA) are published in the 1991 USEPA/USACE guidance document entitled "Ecological Evaluation for Dredged Material Proposed for Ocean Disposal in the Marine Environment". An overview of the Dredged Material Testing Framework is contained in EPA's Ocean Dumping Program Update (1996). Only material that is determined to be "Category 1" material is allowed to be disposed at the HARS. Category 1 material does not show acute toxicity or potential bioaccumulation. As described by EPA, "the acute toxicity of a sediment is determined by quantifying the mortality of appropriately sensitive organisms that are put into contact with the sediment, under either field or laboratory conditions, for a specified period." Also, bioacummulation is described as, "the accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated sediment or water" (EPA 1996). The regulations require that bioaccumulation be considered as part of the environmental evaluation of dredged material proposed for ocean dumping. This consideration involves predicting whether there will be a cause-and-effect relationship between an animal's presence in the area influenced by the dredged material and an environmentally important elevation of its tissue content or body burden of contaminants above that in similar animals not influenced by the disposal of the dredged material."

In addition to the national guidelines, EPA Region 2 and USACE New York District developed a regional implementation manual for New York/New Jersey Harbor entitled "Guidance for Performing Tests on Dredged Material Proposed for Ocean Disposal." This regional manual lists specific contaminants of concern, species approved for use in biological tests, required Quality Assurance /Quality Control and test acceptability parameters, and other pertinent information.

In addition to the Category 1 guidelines, there are specific guidelines that material must achieve in order to be disposed of at the HARS. The HARS' Testing Evaluation Framework includes testing that considers bioaccumulation, bioassay toxicity tests and water column tests. The methodology was developed by ACOE and EPA and has been peer reviewed.

Two sediment-sampling programs were conducted in 2006 and 2008 to gather data about the physical and chemical characteristics of Hudson River sediments at the bridge site (FHWA 2012). Both programs used vibracore samplers to obtain 4-inch-diameter sediment cores from 38 locations. Except where the vibracore device encountered refusal at shallower depths, each vibracore was driven to a depth of at least 6 feet. A total of 156 samples from 38 cores were submitted for sediment chemistry analyses, including Semivolatile Organic Compounds (SVOCs)-base/neutral fraction, pesticides, Polycyclic Aromatic Hydrocarbons (PAHs) and metals. A subset of 17 samples from 10 cores were analyzed for dioxins.

PCBs, Total PAH, mercury, dioxin/furan TEQ, Total DDT, DDD and DDE, arsenic, copper, and cadmium were detected in some samples with concentrations decreasing within 2 to 4 feet of the surface. FHWA compared results from the 2006/2008 sediment sampling to results found for historic Hudson River sampling conducted by Llanso *et al.* (2003). In general, levels of contaminants such as metals, pesticides, and PCBs in the sediment samples collected within the study area are similar to average levels found elsewhere in the Hudson River.

In order for the dredged material to be disposed of at the HARS, it must be tested in accordance with the ACOE and EPA procedures for suitability. Material that can be disposed of at the HARS is specifically selected for its low potential to introduce toxins into the marine environment and for purposes of capping contaminated sediments. Material will not be allowed to be disposed of at HARS that would be acutely or chronically toxic to any aquatic species. Further, the material must not present a risk of bioaccumulation; that is, even if it is not acutely or chronically toxic, it must not increase the potential for bioaccumulation of toxins in higher trophic level species (such as whales or sea turtles) that may prey upon benthic organisms present at the HARS. Because any material that is disposed of at HARS will not be acutely or chronically toxic to aquatic life and will not increase the risk of bioaccumulation, effects to whales and sea turtles of dredged material from the bridge site at HARS will be insignificant and discountable.

4.3 Effects of transport of dredged material to HARS on whales and sea turtles

An ACOE approved Dredged Material Inspector (DMI) is present on board all trips to the HARS. The DMI also serves as a marine mammal/sea turtle observer and monitors for the presence of marine mammals, including large whales, along the transit route and at the disposal site. Disposal of material is prohibited if a marine mammal or sea turtle is seen by the DMI. This requirement is included as a condition in all permits authorizing the use of the HARS.

Although little is known about sea turtle and whale reactions to vessel traffic, these species are thought to be able to avoid injury from slower-moving vessels since the animal has more time to maneuver and avoid the vessel. Vessels will only travel at a speed of less than ten knots while transiting to and from the HARS site.

Large whales, particularly right whales, are vulnerable to injury and mortality from ship strikes. Ship strikes are more likely to occur and more likely to result in serious injury or mortality when vessels are traveling at speeds greater than ten knots. Because the barge will be traveling at speeds below this, the risk of a strike is reduced. The presence of an experienced endangered species observer on board the disposal vessel who can advise the vessel operator to slow the vessel or maneuver safely when listed species are spotted will further reduce the potential for interaction with vessels. Given the low speed that the dredge disposal vessel will operate at and the use of an observer to look out for whales, it is extremely unlikely that any whales will be hit by the dredge vessel. Similarly, we expect that sea turtles will be able to avoid the disposal vessel and that the presence of an observer will further reduce the likelihood of any vessel strikes. Therefore, effects of vessel operations on sea turtles and large whales are discountable.

5.0 STATUS OF LISTED SPECIES IN THE ACTION AREA

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

5.1 Shortnose Sturgeon

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

5.1.1 Shortnose sturgeon life history

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, isopods), insects, and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998). Shortnose sturgeon have similar lengths at maturity (45-55 cm fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell *et al.* 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[2] when the freshwater temperatures increase to 8-9°C. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987; Crowder *et al.* 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell *et al.* 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell *et al.* 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female and a mean of 11,568 eggs/kg body weight (Dadswell *et al.* 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days after hatching in comparison to Savannah River larvae that had longer dispersal rates with multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007). Synder (1988) and Parker (2007) considered individuals to be juvenile when they reached 57mm TL. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while

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2 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.

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 7-9.7°C (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 - 15° (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 6.5-18.0°C (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell *et al.* 1984). Between 8° (46.4°F) and 12°C (53.6°F), eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

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

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

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

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

5.1.2 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)[3] 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

3 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.

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

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

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

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

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

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

Based on the best available information (Bowers-Altman *et al.* 2012 in draft) trends in abundance for shortnose sturgeon in Northeast Rivers demonstrate the majority of populations are stable (i.e., Delaware, Hudson, Connecticut, Merrimack). The Kennebec River Complex is the only population in the Northeast that shows an increasing trend in abundance. In the Southeast, abundance trends for many riverine populations are unknown due to lack of data (i.e., Chowan, Tar Pamlico, Neuse, New, North, Santee, Santee-Cooper system, Satilla, St. Mary's, and St. John's). The Winyah Bay Complex, Cooper, Savannah, Ogeechee, and Altamaha Rivers show stable trends in abundance. The only riverine population in the Southeast demonstrating increasing trends in abundance is the ACE Basin. The species overall is considered to be stable.

5.1.3 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 28°C. 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 28°C (82.4°F) (Flourney *et al.* 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

5.1.4 Status of Shortnose Sturgeon in the Hudson River

The action area is limited to the reach of the Hudson River and the New York Bight where direct and indirect effects of the Tappan Zee bridge replacement project will be experienced, as described in the "Action Area" section above. Shortnose sturgeon in the Gulf of Maine are known to make nearshore coastal migrations between rivers; 71% of shortnose sturgeon tagged in the Penobscot River made regular seasonal movements out of the river, with some fish spending up to a year outside of the river. These types of nearshore coastal movements have only been documented twice in the New York Bight (two fish have been documented to move between the Connecticut and Hudson rivers). Regular coastal between-river movements have only been documented in areas with shared estuaries or when rivers are in close geographic proximity. At this time, the available tagging and tracking information indicates that Hudson River shortnose sturgeon are not making regular movements outside of the Hudson River. The documented movements of two Hudson River fish outside of the river since the mid-1990s is thought to be a reflection of the rarity of these types of movements. Any occurrence of Hudson River fish outside of the river is likely to be extremely rareAs such, we do not expect shortnose sturgeon to occur in portions of the action area outside of the Hudson River. No shortnose sturgeon are expected to occur at the HARS site or along the transit route south of New York Harbor. This section discusses 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 over the last several years (ASA 1999-2002; Dynegy 2003) suggesting that the range of shortnose sturgeon is extending downstream. Shortnose sturgeon were documented as far south as the Manhattan/Staten Island area in June, November and December 2003 (Dynegy 2003).

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

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

In approximately late March through mid-April, when water temperatures are sustained at 8°-9° C (46.4-48.2°F) for several days[4], reproductively active adults begin their migration upstream to the spawning grounds that extend from below the Federal Dam at Troy to about Coeymans, NY (rkm 245-212 (RM 152-131) (Dovel *et al.* 1992). The spawning grounds are located more than 169 km (109 miles) upstream from the Tappan Zee Bridge. Spawning typically occurs at water temperatures between 10-18°C (50-64.4°F) (generally late April-May) after which adults disperse quickly down river into their summer range. Dovel *et al.* (1992) reported that spawning fish tagged at Troy were recaptured in Haverstraw Bay in early June. The broad summer range occupied by adult shortnose sturgeon extends from approximately rkm 38 to rkm 177 (RM 23.5-110). The Tappan Zee Bridge (at rkm 43) is located within the broad summer range.

There is scant data on actual collection of early life stages of shortnose sturgeon in the Hudson River. During a mark recapture study conducted from 1976-1978, Dovel *et al.* (1979) captured larvae near Hudson, NY (rkm 188, RM 117) and young of the year were captured further south near Germantown (RM 106, rkm 171). Between 1996 and 2004, approximately 10 small shortnose sturgeon were collected each year as part of the Falls Shoals Survey (FSS) (ASA 2007). Based upon basic life history information for shortnose sturgeon it is known that eggs adhere to solid objects on the river bottom (Buckley and Kynard 1981; Taubert 1980) and that eggs and larvae are expected to be present within the vicinity of the spawning grounds (rkm 245-212, RM 152-131) for approximately four weeks post spawning (i.e., at latest through mid-June). Shortnose sturgeon larvae in the Hudson River generally range in size from 15 to 18 mm (0.6-0.7 inches) TL at hatching (Pekovitch 1979). Larvae gradually disperse downstream after hatching, entering the tidal river (Hoff *et al.* 1988). Larvae or fry are free swimming and typically concentrate in deep channel habitat (Taubert and Dadswell 1980; Bath *et al.* 1981; Kieffer ad Kynard 1993). Given that fry are free swimming and foraging, they typically disperse downstream of spawning/rearing areas. Larvae can be found upstream of the salt wedge in the Hudson River estuary and are most commonly found in deep waters with strong currents, typically in the channel (Hoff *et al.* 1988; Dovel *et al.* 1992). Larvae are not tolerant of saltwater and their occurrence within the estuary is limited to freshwater areas. The transition from the larval to juvenile stage generally occurs in the first summer of life when the fish grows to approximately 2 cm (0.8 in) TL and is marked by fully developed external characteristics (Pekovitch 1979).

Similar to non-spawning adults, most juveniles occupy the broad region of Haverstraw Bay (rkm 55-64.4) RM 34-40 by late fall and early winter(Dovel *et al.* 1992; Geoghegan *et al.* 1992); the

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

Tappan Zee Bridge is located 12 km downstream of the southern edge of the bay. Migrations from the summer foraging areas to the overwintering grounds are triggered when water temperatures fall to 8°C (46.4°F) (NMFS 1998), typically in late November[5]. 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).

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

5.2 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.

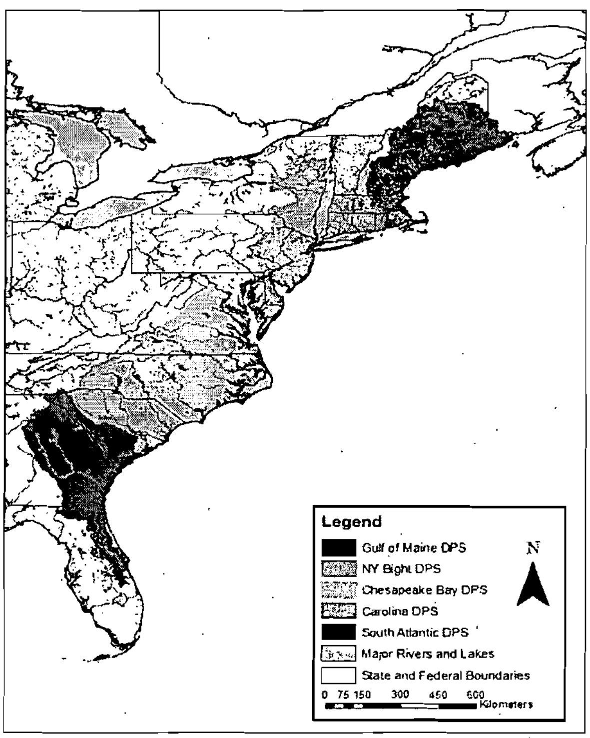
The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers.

5 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.

comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs[6] (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 9). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the 5 DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

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

Figure 9. Map Depicting the Boundaries of the five Atlantic sturgeon DPSs



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

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

5.2.1 Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[7] 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 (developed from information in ASSRT 2007).

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

Table 5. Descriptions of Atlantic sturgeon life history stages.

They are a relatively large fish, even amongst sturgeon species (Pikitch *et al.*, 2005). Atlantic sturgeons are bottom feeders that suck food into a ventrally-located protruding mouth (Bigelow and Schroeder, 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder, 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and

7 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)

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.

5.2.2 Determination of DPS Composition in the Action Area

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

5.2.3 Distribution and Abundance

Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing in the mid to late 19th century when a caviar market was established (Scott and Crossman, 1973; Taub, 1990; Kennebec River Resource Management Plan, 1993; Smith and Clugston, 1997; Dadswell, 2006; ASSRT, 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware, and at least 10,000 females for other spawning stocks (Secor and Waldman, 1999; Secor, 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 16 U.S. rivers are known to support spawning based on available evidence (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT, 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only four rivers (Kennebec, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia where historical records support there used to be fifteen spawning rivers (ASSRT, 2007). Thus, there are substantial gaps in the range between Atlantic sturgeon spawning rivers amongst northern and mid-Atlantic states which could make recolonization of extirpated populations more difficult.

There are no current, published population abundance estimates for any of the currently known spawning stocks. Therefore, there are no published abundance estimates for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson, 2006). Using the data collected from the Hudson River and Altamaha River to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley, 1963; Smith, 1985; Van Eenennaam *et al.*, 1996; Stevenson and Secor, 1999; Collins *et al.* 2000; Caron *et al.*, 2002), the age structure of these populations is not well understood, and stage to stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (e.g., yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT, 2007).

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

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

We were able to use this estimate of the adult population in the Hudson River and the rate at which Atlantic sturgeon from the Hudson River are intercepted in certain Northeast commercial fisheries[8] to estimate the number of adults in other spawning rivers. As noted above, the method used is summarized below and explained fully in Damon-Randall 2012(b).

Given the geographic scope of commercial fisheries as well as the extensive marine migrations of Atlantic sturgeon, fish originating from nearly all spawning rivers are believed to be intercepted by commercial fisheries. An estimate of the number of Atlantic sturgeon captured in certain fisheries authorized by NMFS under Federal FMPs in the Northeast is available (NEFSC 2011). This report indicates that based on observed interactions with Atlantic sturgeon in sink gillnet and otter trawl fisheries from 2006-2010, on average 3,118 Atlantic sturgeon are captured in these fisheries each year. Information in the Northeast Fisheries Observer Program (NEFOP) database, indicates that 25% of captured Atlantic sturgeon are adults (determined as length greater than 150 cm) and 75% are subadults (determined as length less than 150cm). By applying the mixed stock genetic analysis of individuals[9] sampled by the NEFOP and At Sea Monitoring Program (see Damon-Randall *et al.* 2012a) to the bycatch estimate, we can determine an estimate of the number of Hudson River Atlantic sturgeon that are intercepted by these fisheries on an annual basis.

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[8] Bycatch information was obtained from a report prepared by NMFS' Northeast Fisheries Science Center (NEFSC 2012).

[9] Based on the best available information, we expect that 46% of Atlantic sturgeon captured in Northeast commercial fisheries originate from the New York Bight DPS and that 91% of those individuals originate from the Hudson River (see Damon-Randall *et al.* 2012a and Wirgin and King 2011).

Given the number of observed Hudson River origin Atlantic sturgeon adults taken as bycatch, we can calculate what percentage of Hudson River origin Atlantic sturgeon mature adults these represent. This provides an interception rate. We assume that fish originating in any river in any DPS are equally likely to be intercepted by the observed commercial fisheries; therefore, we can use this interception rate to estimate the number of Atlantic sturgeon in the other rivers of origin. This type of back calculation allows us to use the information we have for the Hudson River and fill in significant data gaps present for the other rivers. Using this method, we have estimated the total adult populations for three DPSs (Gulf of Maine, Chesapeake Bay, and South Atlantic) as follows. We are not able to use this method to calculate an adult population estimate for the Carolina DPS. Based on the results of the genetic mixed stock analysis, fish originating from the Carolina DPS do not appear in the Northeast Fisheries Observer Program (NEFOP) observer dataset and based on this, as well as genetics information on fish captured in other coastal sampling programs in the Northeast[10] are assumed to not be intercepted in Northeast fisheries. Given the proportion of adults to subadults in the observer database (ratio of 1:3), we can also estimate a number of subadults originating from each DPS. However, this can not be considered an estimate of the total number of subadults because it would only consider those subadults that are of a size vulnerable to captured in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment.

Table 6: Summary of Calculated Population Estimates

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

5.2.4 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).

Based on the best available information, NMFS has concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all of the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from the Labrador, Canada to Cape Canaveral, FL, as well as

[10] We reviewed genetics information available for 701 individuals sampled in a variety of coastal sampling programs from Maine to Virginia. Only two fish were identified as Carolina DPS origin (collected in central Long Island Sound) and no fish in the NEFOP database (n=89 for genetic samples) were identified as Carolina DPS origin.

estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, given that Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

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

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO, 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO, 2010; Wirgin and King, 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian directed Atlantic sturgeon fisheries and of Canadian fish incidentally in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

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

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

5.3 Gulf of Maine DPS

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

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

Several threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the

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

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

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

Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

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

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

Summary of the Gulf of Maine DPS

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

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

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

5.4 New York Bight DPS

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco, 1977; Secor, 2002; ASSRT, 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT, 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

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

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

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

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

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

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

Historical records from the 1830's indicate Atlantic sturgeon may have spawned as far north as Bordentown, just below Trenton, NJ (Pennsylvania Commission of Fisheries, 1897). Cobb (1899) and Borden (1925) reported spawning occurring between rkm 77 and 130 (Delaware City, DE to Chester City, PA). Based on recent tagging and tracking studies carried out from 2009-2011, Breece (2011) reports likely spawning locations at rkm 120-150 and rkm 170-190. Mature adults have been tracked in these areas at the time of year when spawning is expected to occur and movements have been consistent with what would be expected from spawning adults. Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat also exists from Tinicum Island (rkm 136) to the fall line in Trenton, NJ (rkm 211). To date, eggs and larvae have not been documented to confirm that actual spawning is occurring in these areas. However, as noted below, the presence of young of the year in the Delaware River provides confirmation that spawning is still occurring in this river.

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

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

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

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

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

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

Summary of the New York Bight DPS
Atlantic sturgeon originating from the New York Bight DPS spawn in the Hudson and Delaware rivers. While genetic testing can differentiate between individuals originating from the Hudson or Delaware river the available information suggests that the straying rate is high between these rivers. There are no indications of increasing abundance for the New York Bight DPS (ASSRT, 2009; 2010). Some of the impact from the threats that contributed to the decline of the New York Bight DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). In addition, there have been reductions in fishing effort in state and federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the New York Bight DPS.

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, currently available estimates indicate that at least 4% of adults may be killed as a result of bycatch in fisheries authorized under Northeast FMPs. Based on mixed stock analysis results presented by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid Atlantic Bight region were sturgeon from the New York Bight DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1-2% were from the New York Bight DPS. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects are also not able to quantify any effects to habitat.

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

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

Vessel strikes occur in the Delaware River. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the New York Bight DPS.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. As explained above, we have estimated that there are an annual mean total of 950 mature adult Atlantic sturgeon in the NYB DPS. NMFS has determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

5.5 Chesapeake Bay DPS

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

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

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

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

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

Summary of the Chesapeake Bay DPS

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

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

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

There are several activities that occur in the Hudson River that affect individual shortnose and Atlantic sturgeon. Impacts of activities that occur within the action area are considered in the "Environmental Baseline" section (Section 6.0, below). Activities that impact sturgeon in the Hudson River but do not necessarily overlap with the action area are discussed below.

5.6.1 Hudson River Power Plants

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

5.6.1.1 Indian Point

IP1 operated from 1962 through October 1974. IP2 and IP3 have been operational since 1973 and 1975, respectively. Since 1963, shortnose and Atlantic sturgeon in the Hudson River have been exposed to effects of this facility. Eggs and early larvae would be the only life stages of sturgeon small enough to be vulnerable to entrainment at the Indian Point intakes (openings in the wedge wire screens are 6mm x 12.5 mm (0.25 inches by 0.5 inches); eggs are small enough to pass through these openings but are not expected to occur in the immediate vicinity of the Indian Point site.

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

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

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

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

The Indian Point facility may be relicensed in the future; if so, it could operate until 2033 and 2035. NRC is currently considering Entergy's application for a new operating license. NRC's proposed action was the subject of a section 7 consultation with NMFS that concluded in October 2011. In our Biological Opinion, we considered the effects of the continued operation of the facility from the time a new license is issued (2013 and 2015 for Units 2 and 3 respectively) through the 20 year extended operating period (2033 and 2035) on shortnose sturgeon. We determined that the proposed action was likely to adversely affect, but not likely to jeopardize, the continued existence of shortnose sturgeon. As explained in the "Effects of the Action" section of that Opinion, an average of 5 shortnose sturgeon per year are likely to be impinged at Unit 2 during the extended operating period, with a total of no more than 104 shortnose sturgeon over the 20 year period (dead or alive). Additionally, over the 20 year operating period, an additional 6 shortnose sturgeon (dead or alive) are likely to be impinged at the Unit 1 intakes which will provide service water for the operation of Unit 2. At Unit 3, an average of 3 shortnose sturgeon are likely to be impinged per year during the extended operating period, with a total of no more than 58 shortnose sturgeon (dead or alive) taken as a result of the operation of Unit 3 over the 20 year period. This level of take was exempted through an Incidental Take Statement that applies only to the period when the facility operates under a new operating license (September 28, 2013 through September 28, 2033 for Units 1 and 2; December 12, 2015 through December 12, 2035 for Unit 3). It is likely that the operation of Indian Point continues to cause the impingement, and possible mortality, of some number of individual Atlantic sturgeon in the Hudson River; on May 16, 2012, NRC requested reinitiation of the 2011 consultation to consider Atlantic sturgeon. This consultation is currently ongoing.

5.6.1.2 Roseton and Danskammer

In 1998, Central Hudson Gas and Electric Corporation (CHGEC), the operator of the Roseton and Danskammer Point power plants initiated an application with us for an incidental take (ITP) permit under section 10(a)(1)(B) of the ESA.[11] As part of this process CHGEC submitted a Conservation Plan and application for a 10(a)(1)(B) incidental take permit that proposed to minimize the potential for entrainment and impingement of shortnose sturgeon at the Roseton and Danskammer Point power plants. These measures ensure that the operation of these plants will not appreciably reduce the likelihood of the survival and recovery of shortnose sturgeon in the wild. In addition to the minimization measures, a proposed monitoring program was implemented to assess the periodic take of shortnose sturgeon, the status of the species in the project area, and the progress on the fulfillment of mitigation requirements. In December 2000, Dynegy Roseton L.L.C. and Dynegy Danskammer Point L.L.C. were issued incidental take permit no. 1269 (ITP 1269). At the time the ITP was issued, Atlantic sturgeon were not listed under the ESA; therefore, the ITP does not address Atlantic sturgeon.

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

6.0 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

11 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.

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.

6.1 Federal Actions that have Undergone Formal or Early Section 7 Consultation

Some of the actions noted below occur only in the Hudson River and some occur in waters outside the river (e.g., Federal fisheries). Actions that occur in the Hudson River may affect shortnose and Atlantic sturgeon. Given the range of shortnose sturgeon, activities outside the Hudson River and upper New York Harbor are only likely to affect Atlantic sturgeon.

6.1.1 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.

NYDEC 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). NYDEC is authorized to use gillnets and trawls to capture up to 240 and 2,340 shortnose sturgeon in year one through years three and four and five, respectively. Research activities include: capture; measure, weigh; tag with passive integrated transponder (PIT) tags and Floy tags, if untagged; and sample genetic fin clips. A first subset of fish will also be anesthetized and tagged with acoustic transmitters; a second subset will have fin rays sampled for age and growth analysis; and a third subset will have gastric contents lavaged for diet analysis, as well as blood samples taken for contaminants. 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, NYDEC was issued a scientific research permit (#16436) which authorizes the capture, handling and tagging of Atlantic sturgeon in the Hudson River. NYDEC 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[12] in 2007 (#1580, originally issued as #1254) to evaluate the life history, population trends, and spacio-temporal and size distribution of shortnose sturgeon collected during the annual Hudson River Biological Monitoring Program. Dynegy is authorized to capture up to 82 adults/juveniles annually to measure, weigh, tag, photograph, and collect tissue samples for genetic analyses. Dynegy is also authorized to lethally take up to 40 larvae annually. An application for a new permit to authorize continuation of this sampling program was submitted by Entergy in 2012 and is currently under review. It is anticipated that any new permit issued would authorize takes of shortnose and Atlantic sturgeon.

6.1.2 Federally Authorized Fisheries

NMFS authorizes the operation of several fisheries in the action area under the authority of the Magnuson-Stevens Fishery Conservation Act and through Fishery Management Plans (FMP) and their implementing regulations. The action area includes a portion of NOAA Statistical Area 612. Fisheries that operate in the action area that may affect Atlantic sturgeon include: American lobster, Atlantic bluefish, Atlantic herring, Atlantic mackerel/squid/ butterfish, Atlantic sea scallop, monkfish, northeast multispecies, spiny dogfish, surf clam/ocean quahog and summer flounder/scup/black sea bass. Section 7 consultations have been completed on these fisheries to consider effects to listed whales and sea turtles.

We are in the process of reinitiating consultations that consider fisheries actions that may affect Atlantic sturgeon. Atlantic sturgeon are known to be captured and killed in fisheries operated in the action area; of the fisheries noted above, we expect that interactions may occur in all except American lobster, Atlantic herring and surf clam/ocean quahog. Data in the NEFOP database (see NEFSC 2011) indicates that captures of Atlantic sturgeon in fishing gear has been reported in all months in area 612. At the time of this writing, no Opinions considering effects of federally authorized fisheries on any DPS of Atlantic sturgeon have been completed. As noted in the Status of the Species section above, the NEFSC prepared a bycatch estimate for Atlantic sturgeon captured in sink gillnet and otter trawl fisheries operated from Maine through Virginia. This estimate indicates that, based on data from 2006-2010, annually, an average of 3,118 Atlantic sturgeon are captured in these fisheries with 1,569 in sink gillnet and 1,548 in otter trawls. The mortality rate in sink gillnets is estimated at approximately 20% and the mortality rate in otter trawls is estimated at 5%. Based on this estimate, a total of 391 Atlantic sturgeon are estimated to be killed annually in these fisheries that are prosecuted in the action area. We are currently in the process of determining the effects of this annual loss to each of the DPSs.

6.1.3 Other Research Activities

We have completed ESA section 7 consultation on two other research projects that occur in the action area. The US Fish and Wildlife Service funds an ocean trawl survey carried out by the State of New Jersey; the project is currently funded through May 3, 2014. This federal action was the subject of a consultation completed in May 2012. In the Opinion, we concluded that the action may adversely affect, but was not likely to jeopardize the continued existence of any DPS of Atlantic sturgeon. The ITS exempts the take of 109 Atlantic sturgeon through May 2014. All captured Atlantic sturgeon are expected to be released alive and no lethal take is anticipated.

12 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."

We provide funding to the Virginia Institute of Marine Science (VIMS) to carry out the Northeast Area Monitoring and Assessment Program (NEAMAP) Near Shore Trawl Program. In an April 2012 Opinion, we concluded that the 2012 spring and fall surveys may adversely affect, but was not likely to jeopardize the continued existence of any DPS of Atlantic sturgeon. The ITS exempts the take of 32 Atlantic sturgeon through 2012. All captured Atlantic sturgeon are expected to be released alive and no lethal take is anticipated.

6.1.4 HARS site

Background information on the HARS site is provided in sections 3.4.4 and 4.2 above. Over the past century, dredged material from the Port of New York and New Jersey was routinely disposed of at the Mud Dump Site (MDS), which is located within the current HARS site. The EPA formally designated the MDS as an "interim" ocean dredged material disposal site in 1973, and gave it final designation in 1984. On September 29, 1997, EPA under 40 CFR §228, closed MDS and simultaneously re-designated the site and surrounding areas that were used historically as disposal sites for contaminated dredged material as the HARS, and proposed that the site be managed to reduce impacts to acceptable levels (in accordance with 40 CFR §228.1(c)) (62 FR 46142) through remediation with uncontaminated dredged material (Remediation Material).

EPA published final rule 67 FR 62659 on March 17, 2003, to modify the designation of the HARS to establish a HARS-specific worm tissue polychlorinated biphenyl (PCB) criterion of 113 parts per billion (ppb) for use in determining the suitability of proposed dredged material for use as Remediation Material. This amendment to the HARS designation established a pass/fail criterion for evaluating PCBs in worm tissue from bioaccumulation tests performed on dredged material proposed for use at HARS as Remediation Material (USACE and USEPA 2009).

Pursuant to NEPA, EPA Region 2 prepared a Supplement to the Environmental Impact Statement (SEIS) on the Dredged Material Disposal Site Designation for the Designation of the HARS in 1997 (USEPA 1997). EPA prepared a BA that concluded that the closure of the Mud Dump Site and designation of the HARS was not likely to adversely affect loggerhead and kemps ridley sea turtles and humpback and fin whales (USEPA 1997). Special conditions are included in USACE Section 103 permits for placement of Remediation Material at HARS that requires the presence of NMFS approved Endangered Species Observer(s) on disposal scows during their trips to the HARS. The role of these observers is to prevent adverse impacts to endangered or threatened species transiting the area between the proposed dredge site and the HARS. In a letter dated July 30, 1997, we concurred with the EPA's determination and noted that while the BA did not consider right whales, our conclusions also applied to right whales. EPA is in the process of assessing the continued use of the HARS on Atlantic sturgeon and is in the process of preparing a BA and consultation request.

6.1.5 New York Harbor Deepening Project

The Harbor Deepening Project (HDP) was authorized pursuant to the Water Resources Development Act of 2000 and is an ongoing (since 2005) Federal dredging project that will deepen several channels in the Port of New York and New Jersey to a depth of approximately 50 feet below mean low water, thereby enabling the safe navigation and access of the Port by deep draft vessels. The HDP involves deepening channels and management of the dredged material produced by these operations (i.e., several different placement options for the dredged material are and will be utilized: upland sites; the Newark Bay Confined Disposal Facility (NBCDF); HARS; reef sites (i.e., Atlantic Beach artificial reef, New York; Sandy Hook artificial reef, New Jersey); habitat creation and other beneficial uses (e.g., Plumb Beach storm damage reduction, restoration Yellow Bar, Black Wall, and Rulers Bar Islands).

On February 18, 2000, consultation was initiated, with a Biological Opinion (Opinion) issued by us to the ACOE on October 13, 2000. In this Opinion we concluded that the HDP was likely to adversely affect but was not likely to jeopardize the continued existence of loggerhead, Kemp's ridley, leatherback or green sea turtles. The Opinion included an ITS exempting the incidental take of two loggerhead, one green, one Kemp's ridley, or one leatherback for the duration of the deepening, via a hopper dredge, of the Ambrose Channel. Due to the proposed method of dredging (i.e., clamshell bucket dredge or hydraulic cutterhead dredge) and location to unsuitable sea turtle habitat, dredging activities in Anchorage Channel, Bay Ridge Channel, Port Jersey Channel, Kill van Kull, Arthur Kill, and Newark Bay Channels are not expected to result in any lethal or non-lethal take of sea turtles. The ACOE is currently preparing a BA to consider effects of the remaining HDP work on Atlantic sturgeon; we expect consultation to be reinitiated in summer 2012. No interactions with Atlantic sturgeon during the HDP have been observed to date.

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

6.1.7 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 ACOE. This includes several dock and pier projects. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

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

6.2 State or Private Actions within the Action Area

6.2.1 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.

6.2.2 State Authorized Fisheries

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

American Eel

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

Atlantic croaker

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

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

Coastal sharks

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

Horseshoe crabs

ASMFC manages horseshoe crabs through an Interstate Fisheries Management Plan that sets state quotas, and allows states to set closed seasons. New York is allowed 366,272 crabs by the ASMFC under Addendum IV, but has issued a lower state quota of 170,000. Commercial horseshoe crab harvester may take 30 crabs per day during the open season by hand harvest or with pound nets, trap nets, gillnets, otter trawls, seines, or dredges. The use of dredges is prohibited in September and October, and dredges are limited to six feet in width at other times. Recreational harvesters are allowed to take five crabs per person per day, all year. Once the

ASMFC quota is reached, the fishery is closed. Trawls are known to incidentally capture Atlantic sturgeon. Stein *et al.* (2004) examined bycatch of Atlantic sturgeon using the NMFS sea-sampling/observer database (1989-2000) and found that the bycatch rate for horseshoe crabs was very low, at 0.05%. Few Atlantic sturgeon are expected to be caught in the horeshoe crab fishery in the action area.

Shad and River herring

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

Striped bass

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

Weakfish

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

A quantitative assessment of the number of Atlantic sturgeon captured in the weakfish fishery is not available. A review of the NEFOP database indicates that from 2006-2010, 36 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as weakfish. This represents a minimum number of Atlantic sturgeon captured in the weakfish fishery during this time period as it only considers observed trips, and most inshore fisheries are not observed. An earlier review of bycatch rates and landings for the weakfish fishery reported that the weakfish-striped bass fishery had an Atlantic sturgeon bycatch rate of 16% from 1989-2000; the weakfish-Atlantic croaker fishery had an

Atlantic sturgeon bycatch rate of .02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007). No information on interactions between shortnose sturgeon and the weakfish fishery is available; however, because shortnose sturgeon can be caught in hook and line fisheries as well as in otter trawls, if this gear is used in areas of the river and estuary where shortnose sturgeon are present, there could be some capture of shortnose sturgeon in this fishery.

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

6.3 Other Impacts of Human Activities in the Action Area

6.3.1 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.)

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

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

Atlantic sturgeon adults are likely to migrate through the portion of the action area where construction will take place in the spring as they move from oceanic overwintering sites to upstream spawning sites and then migrate back through the area as they move to lower reaches of the estuary or oceanic areas in the late spring and early summer. Atlantic sturgeon adults are most likely to occur in the construction portion of the action area from May – September. Tracking data from tagged juvenile Atlantic sturgeon indicates that during the spring and summer individuals are most likely to occur within rkm 60-170. During the winter months, juvenile Atlantic sturgeon are most likely to occur between rkm 19 and 74. This seasonal change in distribution may be associated with seasonal movements of the saltwedge and differential seasonal use of habitats.

Based on the available data, juvenile, subadult and adult Atlantic sturgeon may be present in the construction portion of the action area year round. In the marine waters where the dredge disposal barge will transit and at the HARS site, only subadult and adult Atlantic sturgeon are likely to be present. While we do not have information on the seasonal distribution of Atlantic sturgeon at the HARS, Atlantic sturgeon have been caught in fisheries operating in Statistical Area 612, in which the HARS is located, in all months of the year. Therefore, we expect that Atlantic sturgeon will be present in the marine waters of the action area during the August 1 – November 1 time period when the HARS is being used. As explained above, Atlantic sturgeon in the action area are likely to have originated from the New York Bight DPS, Chesapeake Bay DPS and Gulf of Maine DPS, with the majority of individuals originating from the New York Bight DPS, and the majority of those individuals originating from the Hudson River.

Shortnose sturgeon juveniles and adults are likely to be present in the Hudson River portion of the action area year round, with the highest numbers present between May and October. At other times of the year, the majority of individuals are expected to be at overwintering sites located outside of the action area. All shortnose sturgeon in the action area are likely to have originated from the Hudson River. Coastal migrations have been documented in the Gulf of Maine, and two individuals tagged in the Hudson River have been caught in the Connecticut River. However, no shortnose sturgeon originating from another river or tagged in another river have been captured or detected in the Hudson River. Based on this, at this time we believe that interbasin movements into the Hudson River are rare. We do not expect shortnose sturgeon to be present in the marine waters of the action area.

7.0 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 sea turtles and 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 8.0 below).

7.1 Background Information on predicted climate change

The global mean temperature has risen 0.76°C (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°-5°C (5°-9°F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2°C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene *et al.* 2008, IPCC 2006). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2006). The

NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene *et al.* 2008, IPCC 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene *et al.* 2008).

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

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch *et al.* 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C (0.4°F) per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of DO and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm (6-8 inches).

7.2 Species Specific Information on Climate Change

7.2.1 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.

7.2.2 Atlantic sturgeon

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

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7.3 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.

The Office of the New Jersey State Climatologist has summarized available information on a state-wide basis; this information is relevant to understanding potential effects of climate change at the HARS site and at the coastal transit routes. Although there is much variation from year to year, these data show a statistically significant rise in average statewide temperature (approximately 2 degrees Fahrenheit) over the last 113 years. It is predicted that in the Northeastern US, precipitation, particularly in the form of rainfall, and runoff are expected to increase in future years (NECIA 2007). NOAA tide gauge data reported by the State of New Jeresey indicates that the sea level at the New Jersey coast sites of Atlantic City, Cape May, and Sandy Hook has risen at a rate of approximately 4 mm/y since recording began in the early- to mid-1900s; anthropogenic contribution to the recent higher rate of rise is approximately 2 mm/y, approximately one-half of the total observed rate of rise, which is in line with recent estimates of the global rate.

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 and New Jersey, given the geographic proximity of these waters to the Northeast, we assume that predictions would be similar. 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.

7.3 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. The new Tappan Zee Bridge is predicted to have a lifespan of 100 years before substantial structural replacements would be required; thus, we consider here, likely effects of climate change in the next 100 years.

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.

8.0 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent. Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02; see also 1998 FWS-NMFS Joint Consultation Handbook, pp. 4-26 to 4-28). We have not identified any interrelated or interdependent actions. This Opinion examines the likely effects of the proposed action on shortnose sturgeon and three DPSs of Atlantic sturgeon and their habitat in the action area within the context of the species current status, the environmental baseline and cumulative effects. Because there is no critical habitat in the action area, none will be affected.

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

8.1 Dredging the Access Channel

8.1.1 Overview of Dredging Activity

As described in Section 3.4.2, dredging will occur in three years, between August 1 and November 1. A total of 1.68 - 1.74 million cubic yards (MCY) would be removed from a channel with a width of 145 to 161 m extending approximately 2,133 m (7,000 feet) from the Rockland County side into deeper waters and 610 m (2,000) feet from the Tarrytown access trestle into deeper waters. Approximately 64% of the material (1.08-1.12 MCY) will be removed in Stage 1, 25% (0.42-0.43 MCY) in Stage 2 and 11% (0.18-0.19 MCY) in Stage 3. All dredging will be completed with a closed environmental bucket.

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

8.1.2 Capture of sturgeon in the dredge bucket

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

In rare occurrences sturgeon have been captured in dredge buckets and placed in the scow. Very few mechanical dredge operations have employed observers to document interactions between sturgeon and the dredge; because of that we do not know if the lack of observations is a result of fish not being captured at other projects or that captures occur but are not observed. Captures of two shortnose and one Atlantic sturgeon have been documented at the Bath Iron Works (BIW) facility in the Kennebec River, Maine. It is unknown if these observations are the result of a unique situation in this river or whether interactions have occurred elsewhere but have just been undocumented. Observer coverage at dredging operations at BIW has been 100% for approximately 15 years and three observations of captured sturgeon have been documented. Dredging occurs every one to two years at this location. An Atlantic sturgeon was killed in the Cape Fear River in a bucket and barge operation (NMFS 1998).

Due to the nature of interactions between listed species and dredge operations, it is difficult to predict the number of interactions that are likely to occur from a particular dredging operation. Projects that occur in an identical location with the same equipment year after year may result in interactions in some years and none in other years. For example, dredging in the BIW sinking basin prior to 2003 resulted in no interactions with shortnose sturgeon but one shortnose sturgeon was killed by the clamshell dredge in the last hour of the last day of dredging of a dredge event running from April 7 to April 30, 2003. An additional shortnose sturgeon was captured in this area in 2009, but none were captured between 2003 and 2009 or 2009-2011. Regardless, based on all available evidence, the risk of capture in a mechanical dredge is low due to the slow speed at which the bucket moves and the relatively small area of the bottom it interacts with at any one time.

Based on the occurrence of shortnose and Atlantic sturgeon in the area where mechanical dredging will take place and the documented vulnerability of this species to capture with mechanical dredges, it is likely that a small number of sturgeon will be captured by the mechanical dredge working to dredge the access channel. Due to the relatively low level of risk that an individual shortnose sturgeon would be captured in the slow moving dredge bucket, no more than one shortnose sturgeon and no more than one Atlantic sturgeon is likely to be captured during each year that dredging occurs. As dredging will occur in three years, we expect a total of three or fewer shortnose sturgeon and three or fewer Atlantic sturgeon to be captured during dredging.

Sturgeon captured in the dredge bucket could be injured or killed. Sources of mortality include injuries suffered during contact with the dredge bucket or burial in the dredge scow. Of the three captures of sturgeon with mechanical dredges in the Kennebec River (two shortnose (in 2003 and 2009), one Atlantic (in 2001)), one of the shortnose sturgeon was killed. This fish was killed during the last hour of a 24-hour a day dredging operation that had been ongoing for approximately four weeks. This fish suffered from a large laceration, likely experienced due to contact with the dredge bucket. Of the other two fish, both were observed alive in the dredge scow and were released, with no visible external injuries. Assuming that the risk of mortality once captured is similar across dredging projects, we expect a similar mortality rate at the

Tappan Zee project as has been observed at BIW. Therefore, we expect no more than one of the three captured shortnose sturgeon and no more than one of the three captured Atlantic sturgeon to be injured or killed during dredging operations. Injury or mortality could result from contact with the dredge bucket or through suffocation due to burial in the scow. Because FHWA will require an observer be present to watch for captured fish as sediment is deposited in the scow and to monitor the scow for fish, we expect that any captured sturgeon will be documented. Shortnose sturgeon captured or killed could be juveniles or adults.

During the time of year that dredging will occur (August 1 – November 1), only juvenile and subadult Atlantic sturgeon are likely to be present in the area to be dredged. Therefore, the affected Atlantic sturgeon will be juveniles or subadults. Based on the mixed-stock analysis, it is most likely that all three captured Atlantic sturgeon, including the one that could be killed, would originate from the New York Bight DPS. However, because Atlantic sturgeon from the Chesapeake Bay and Gulf of Maine DPSs are also present in the area where dredging will occur, it is possible that one of the captured or killed fish could originate from either the Chesapeake Bay or Gulf of Maine DPS; these fish would be subadults because juveniles remain in their natal rivers and therefore, juveniles from these DPSs do not occur in the action area.

8.2 Disposal of Dredged Material at HARS

As discussed in Section 4.3 above, dredged material will be transferred to large ocean going scows and towed by tugboat to the HARS disposal area. Shortnose and Atlantic sturgeon are present throughout the Hudson River and could both be present along the transit route as far south as New York Harbor. From New York Harbor to the HARS, only Atlantic sturgeon are expected to be present. During the August 1 – November 1 time period, Atlantic sturgeon in this area are likely to be foraging or migrating between foraging areas. As water temperatures begin to cool in October, Atlantic sturgeon are likely to be moving through the action area to overwintering areas. The HARS is not known to be used for overwintering.

Dredging, and subsequently disposal, would be conducted in three stages, each stage conducted during a separate dredging season occurring within a three-month period from August 1 to November 1. For the Long Span Option, the option with the higher dredging quantities, approximately 1.12 MCY would be disposed of during Stage 1, 0.43 MCY during Stage 2, and 0.19 MCY during Stage 3, for a total of 1.74 MCY. Effects to Atlantic sturgeon from HARS disposal include: turbidity; exposure to contaminants; reduction in available prey; and vessel strikes. The effects of vessel traffic are discussed in Section 7.8 below.

As discussed in Section 4.2, material to be disposed at HARS will be thoroughly screened and tested for its potential to cause toxicity to marine organisms, including species that could serve as forage for Atlantic sturgeon. A summary of sediment sampling programs for contaminants is presented in Section 4.2. In order for the dredged material to be disposed of at the HARS, it must be tested in accordance with the ACOE and EPA procedures for suitability. Material that can be disposed of at the HARS is specifically selected for its low potential to introduce toxins into the marine environment and for purposes of capping contaminated sediments. Material will not be allowed to be disposed of at HARS that would be acutely or chronically toxic to any aquatic species. Further, the material must not present a risk of bioaccumulation; that is, even if it is not acutely or chronically toxic, it must not increase the potential for bioaccumulation of toxins in higher trophic level species (such as Atlantic sturgeon) that may prey upon benthic organisms present at the HARS. Because any material that is disposed of at HARS will not be acutely or chronically toxic to aquatic life and will not increase the risk of bioaccumulation, effects to Atlantic sturgeon of dredged material from the bridge site at HARS will be insignificant and discountable.

For purposes of this consultation, we consider that sediment that is suitable for ocean disposal would not be toxic to marine life and would not be likely to cause adverse effects to Atlantic sturgeon or their prey. Material that can be disposed of at the HARS is specifically selected for its low potential to introduce toxins into the marine environment and for purposes of capping contaminated sediments. Because the material to be disposed will be tested to ensure it is not acutely toxic and will not increase the risk of bioaccumulation of toxins or contaminants in any marine species, effects to Atlantic sturgeon will be insignificant and discountable.

Disposal operations can also affect foraging animals by burying benthic prey. Direct impacts to fish or other mobile species during placement of the dredged material at the HARS would be expected to be minimal due to the small contact footprint of the fluidized sediments as they leave the barge (typically 50 foot by 100 foot). Given the small area impacted by each disposal event, mobile species are expected to be able to avoid the falling sediment and would not be subject to burial. The only species that are likely to be buried are immobile benthic organisms. Some species of benthic invertebrates that Atlantic sturgeon feed on have limited mobility and could be buried during disposal operations; other prey species, such as sand lance, are mobile and would be able to avoid burial.

The loss of potential benthic prey species would be minimized spatially and temporally through use of a grid system for the placement of dredged material. Some buried animals will be able to unbury themselves. Areas where dredged material will be placed are expected to be recolonized by individuals from nearby similar habitats. Because the characteristics of the sediment from the project would be similar to those in and around the HARS, benthic invertebrates would be expected to quickly recolonize the cells used for the placement of this material. Thus, any reduction in benthic prey at the HARS site will be temporary and limited to the small area where dredged material will be placed. The potential loss of prey for Atlantic sturgeon will be extremely small, as only a fraction of the benthic species that Atlantic sturgeon prey on will be affected, and those losses will occur in a very small area. Effects to foraging Atlantic sturgeon will be insignificant.

8.3 Pile Installation

In this section we present: background information on acoustics; a summary of available information on sturgeon hearing; a summary of available information on the physiological and behavioral effects of exposure to underwater noise; and, established thresholds and criteria to consider when assessing impacts of underwater noise. We 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.

8.3.1 Information Used to Conduct the Effects Analysis

8.3.1.1 Basic Background on Acoustics and Fish Bioacoustics

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

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

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

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

The following are commonly used measures of sound:

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

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

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

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

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

8.3.1.2 Summary of Available Information on Underwater Noise and Sturgeon

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

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

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

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

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

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

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

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

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

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

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

8.3.1.3 Criteria for Assessing the Potential for Physiological Effects

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

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

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

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

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

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

8.3.1.4 Available Information for Assessing Behavioral Effects

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

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

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

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

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

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

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

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

Andersson *et al.* (2007) presents information on the response of sticklebacks (*Gasterosteus aculeatus*), a hearing generalist, to pure tones and broadband sounds from wind farm operations. Sticklebacks responded by freezing in place and exhibiting startle responses at SPLs of 120 dB (re: 1 μPa) 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.

8.3.2 Effects of Pile Installation on Sturgeon

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

8.3.2.1 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. FHWA indicates that installation of the piles with a vibratory hammer is expected to produce acoustic footprints similar to driving sheet piles (163 dB re 1 μPa^2-s SEL_{cum} at a distance of 16-ft or the driving of wood piles with an acoustic footprint of 150 dB re 1 μPa^2-s SEL_{cum} within 10 meters of the pile being driven (Jones and Stokes, 2009)). Installation of 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 (i.e., within 10 meters of the pile being installed), it is extremely unlikely that the behavior of any individual sturgeon would be affected by noise associated with the installation of piles with a vibratory hammer. Even if a sturgeon was within 10 meters of the pile being installed, we expect that the behavioral response would, at most, be limited to movement outside the area where noise greater than 150 dB re 1 μPa RMS would be experienced (i.e., moving to an area at least 10 meters from the pile). Because this area is very small and it would take very little energy to make these movements, the effect to any individual sturgeon would be insignificant. Based on this analysis, all effects to shortnose and Atlantic sturgeon exposed to noise associated with the installation of piles with a vibratory hammer will be insignificant and discountable.

8.3.2.2 Noise Associated with the Drilling and Pinning of Piles

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

8.3.2.3 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 7.6.2 above). The "top" section will then be installed with an impact hammer. Noise attenuation systems, which are expected to reduce underwater noise by at least 10 dB (based on PIDP results), will be in place for all piles installed with impact hammers. The driving of individual piles will take 0.33-1.55 hours, assuming that the entire pile is installed with an impact hammer. Because piles are expected to be partially installed with vibratory hammers, this is expected to be an overestimate of the duration of impact hammering. Between April and August, pile driving of the 8 and 10 foot piles with an impact hammer in Zone C (water depths of 18 to 45 feet) will occur for no more than five hours per day. Outside of this time of year, pile driving will occur for up to twelve hours a day. No night-time pile driving will occur.

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 by using computer analyses. This information was presented by FHWA in the BA and the conservatism of the findings was confirmed by the PIDP results.

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

Model runs were specifically made to determine at what distance from the pile underwater acoustic pressures and energies resulting from pile driving operations will equal or exceed a peak level of 206 dB re 1 μPa and when multiple hammer strikes cause in-water cumulative energy levels will exceed 187 dB re: 1μPa^2-s.

Table 7 provides computed peak sound pressure levels for various downrange distances (in feet) from the pile driving noise source at which noise is attenuated to 206 dB re 1μPa (peak) through 182 dB re 1μPa (peak).

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

Pile Diameter (ft)	206 dB re 1 μPA	200 dB re 1 μPA	194 dB re 1 μPA	188 dB re 1 μPA	182 dB re 1 μPA
Pile Installation scenarios with 10 dB broadband noise attenuation					
4	<10	34	59	100	174
8	101	172	277	724	1100
10	166	248	773	1191	1693

As can be seen in Table 7, the 206 dB re 1 μPa (peak) sound pressure levels extend farthest from the pile driving source when a 10-foot diameter pile is driven; the distance from the pile to the point at which peak pressure levels reach 206 dB re 1 μPa is 166 feet. For other pile diameters (4-feet and 8-feet), the distances from the pile to the point in the river at which peak pressure levels fall beneath 206 dB re 1 μPa is considerably less than for the 10-foot diameter pile. Table 7 reflects noise attenuation profiles for modeled scenarios developed for the PIDP. Because the PIDP field tests yielded results that indicated the peak sound pressure levels extend for shorter distances than the modeling predicted, the distances in the table are considered conservative.

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

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

Pile Diameter	Approx. North-South Extent of 187 dB SEL_{CUM} Footprint*	Approx. East-West Extent of 187 dB SEL_{CUM} Footprint*
With attenuation system providing 10 dB noise reduction		
4 feet	1,375	1,650
8 feet	3,875	3,900
10 feet	6,550	4,550
Note: * distance is total length in north-south or east-west direction.		

Similar to the analysis for peak sound pressure levels, the modeling of cumulative sound exposure levels shows that the 10-foot diameter pile, when driven, would generate the largest cSEL acoustic footprint. With the operation of an effective noise attenuation system (assumed at least 10 dB broadband noise reduction), the acoustic footprint of the 10-foot diameter pile would be 6,550 feet (North-South) and 4,550 feet (East-West). For smaller diameter piles, the cSEL acoustic footprint would be notably smaller than for the 10-foot diameter piles. It is important to note that the cSEL value is not a measure of the instantaneous or maximum noise level, but is a measure of the accumulated energy over a period of time. FHWA has indicated that the cSEL values include the number of pile strikes necessary to install the entire pile. The number of strikes is 1,000 – 3,800 depending on the size of the pile. Thus, for the cSEL to be a relevant criterion when considering effects to fish, we would have to expect the fish to remain in the exposure area for the entire duration of time that the pile factored into the equation used to calculate cSEL.

Table 9 provides estimates of the spatial extent of the 150 dB re 1 μPa RMS SPL isopleth that would be generated by driving 4-foot, 8-foot, and 10-foot piles with noise attenuation measures in place. This is also illustrated in Figure 10, below.

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

Non-ensonified river width beyond the 150 db rms SPL isopleth generated during pile-driving with an impact hammer and 10-dB BMP reduction.

Pile size (feet)	Maximum distance from pile to 150-dB rms SPL isopleth (feet)*	North-South extent (feet)**	East-West extent (feet)**	Non-ensonified river width (feet)**
4	1,800	3,500	3,600	11,000
6	3,000	6,500	5,500	8,625
8	4,200	10,000	7,875	6,625
10	7,000	18,750	9,625	4,375

*Based on Figure 29 of JASCO (2011).
**Based on modeled noise isopleths depicted in section C.2 of Appendix to JASCO (2011).

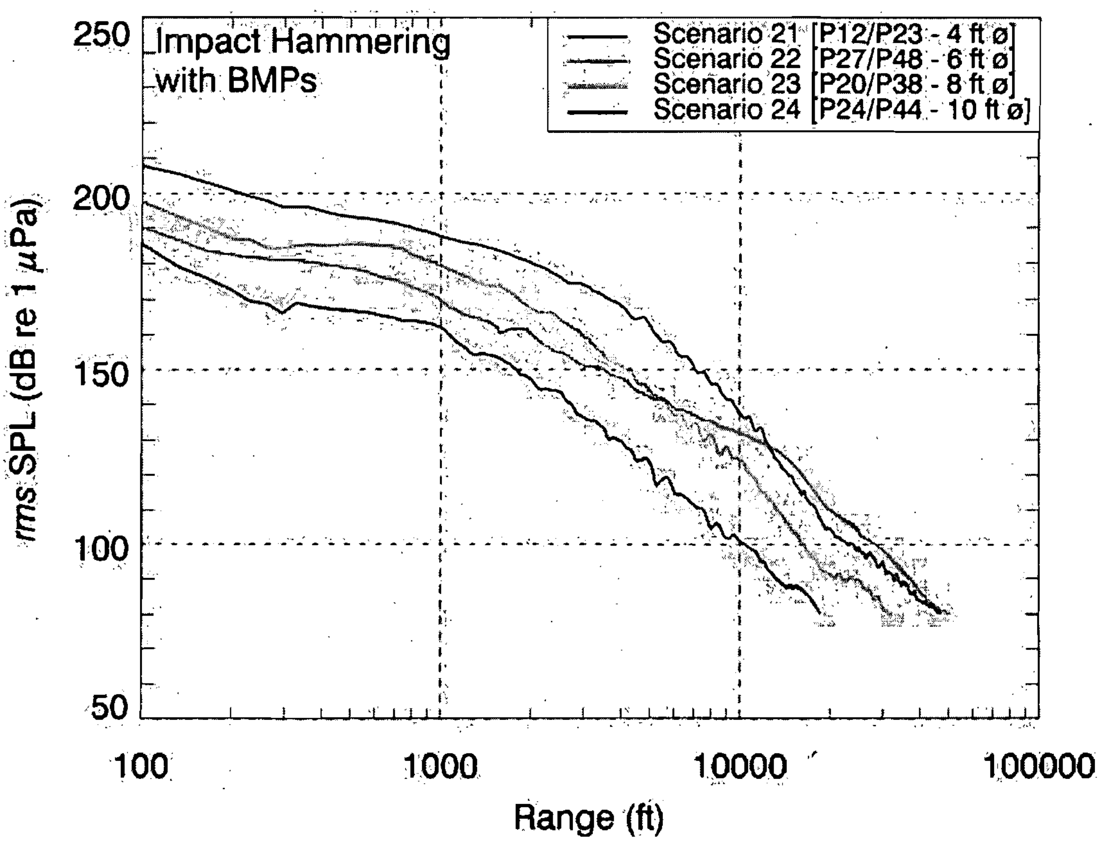

Figure 10. Extent of rms SPL for various sizes of piles.

Various pile driving scenarios were used to generate the cumulative sound exposure level (SEL_{cum}) and peak SEL levels for each day over the construction period. These tables take into account days when multiple piles are being driven and times when more than one pile is being driven at a time. This information is presented in Tables 10, 11, 12 and 13 below. In addition, the application of Best Management Practices (BMPs) that provided a 10 dB reduction in sound was incorporated into the acoustic modeling effort. These practices represent various methods to reduce the extent to which a waterbody would be ensonified by pile driving operations. Various BMPs have been employed on pile driving operations around the country, including air bubble curtains of various forms, isolation casings, Gunderbooms, and dewatered cofferdams. These BMPs were tested during the PIDP; a method that provides at least a 10 dB reduction in underwater noise will be implemented during all pile driving for bridge construction. Preliminary findings from the PIDP confirm that the technologies tested in the field exceed the 10dB noise attenuation target. Furthermore, the PIDP results indicated that the ensonified zones within the 206 dB re 1uPa peak SPL, and the 187 dB re 1uPa s cSEL, and the 150 dB re 1uPa RMS SPL, were all much smaller than had been predicted by the JASCO models.

Figure 11 presents the peak SPL, with BMPs, for 4-, 6-, 8-, and 10-ft piles being driven at representative locations along the alignment of the replacement bridge. The figure illustrates the transmission loss that would occur as distance from the pile driving site increases. Transmission loss is not uniform across the different size piles since the piles would be driven at locations where water depth and other environmental factors vary. For the 4-ft piles, sound above the interim 206 dB peak threshold encompasses a distance of about 35 ft; for the 10-ft piles the 206 dB peak SPL the distance increases to approximately 300 ft.

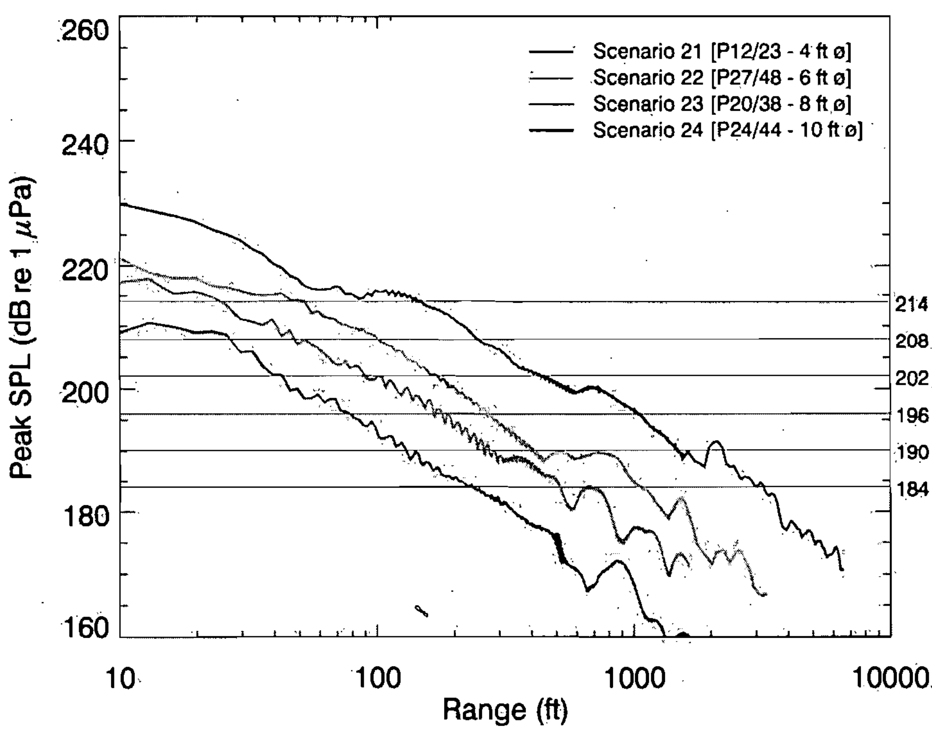

Figure 11. Peak SPL, with 10 dB BMPs, for 4-, 6-, 8-, and 10-ft piles being driven at representative locations along the alignment of the replacement bridge.

Figure 12 presents the SEL_{cum} that results for simultaneously installing two 10-ft piles at the replacement bridge main span over the number of strikes that are predicted to be needed to fully seat the piles; this represents the worst case scenario during project construction. The concentric "circles" (or isopleths) of different colors represent distances from the pile driving activity at which various accumulated sound energy levels (SEL_{cum}) would be reached over the duration of driving of the two piles. For example, the 187 dB isopleths extends over a mile in each direction north and south of the point of pile driving and 49% of the cross sectional width of the river. This can be contrasted with the 187 dB re 1 $\mu Pa^2 \cdot s$ isopleth profile for installing four 4-ft piles at the replacement bridge main span in one day, which does not extend substantial distances in any direction (see Figure 13).

Both of these figures present accumulated energy (SEL_{cum}) for driving a pile over the time for driving the pile. Thus, the information in these figures does *not* represent the energy from a single strike or the instantaneous level of sound at any one moment in time (as represented for peak levels in Figure 9). Instead, it represents the final energy, accumulated over time, of a large number of strikes with a particular SEL_{ss}. Moreover, the accumulated energy in the following figures represents the received energy for an animal *only* if the animal stays in the same location for the duration of the pile driving activity. It should also be understood that the expression SEL_{cum} represents the total energy at a particular location in the river for a discrete duration associated with a particular pile driving operation. For these calculations, the cSEL incorporates the number of strikes necessary to install the entire pile; this will occur over a period of 0.33 – 1.5 hours depending on the pile.

A.2.4. Typical Case 1 (also dual level bridge)

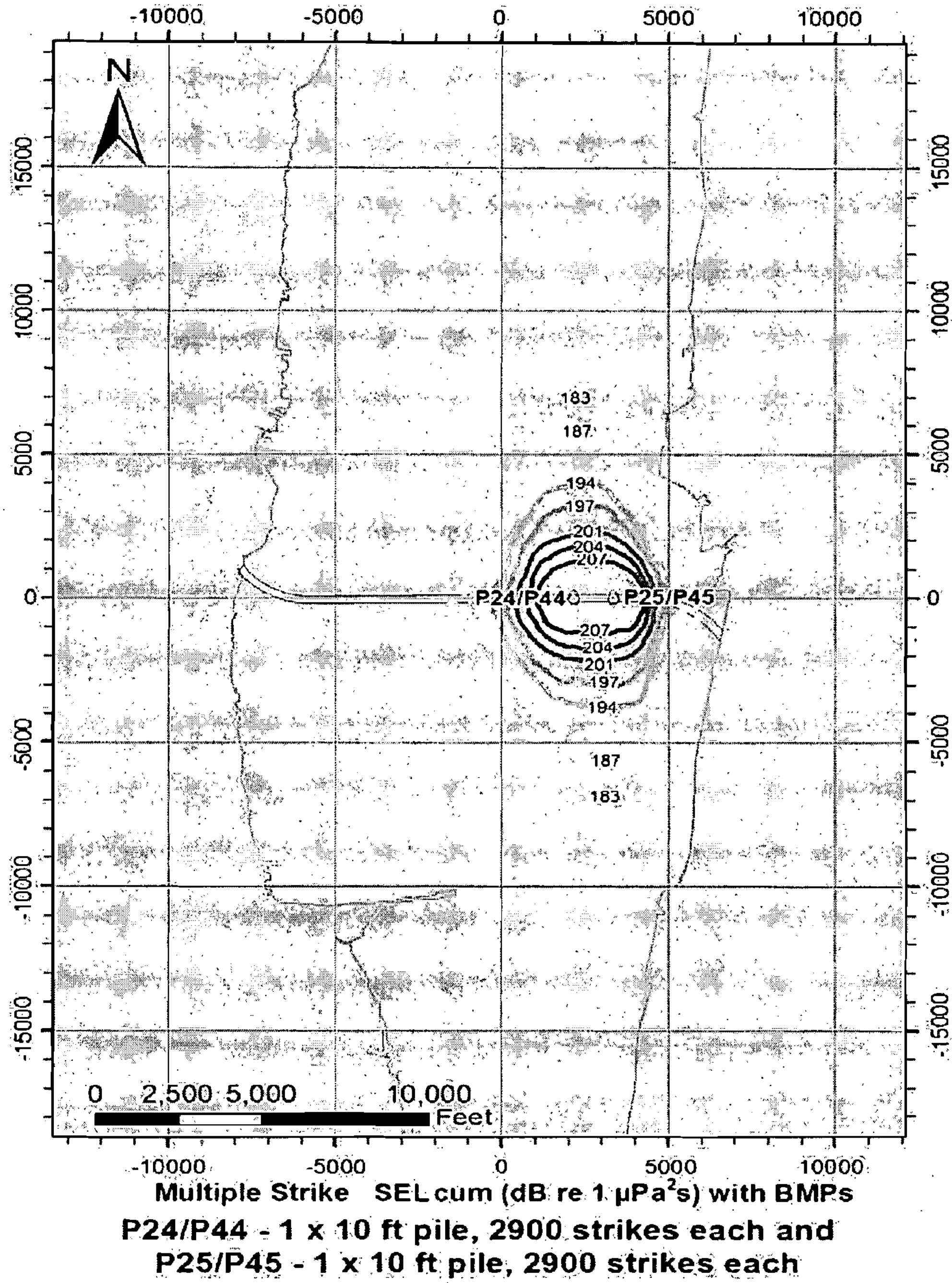

Figure 12. cSEL for installation of two 10-foot diameter piles simultaneously.

A.2.6. Typical Case 3 (also dual level bridge)

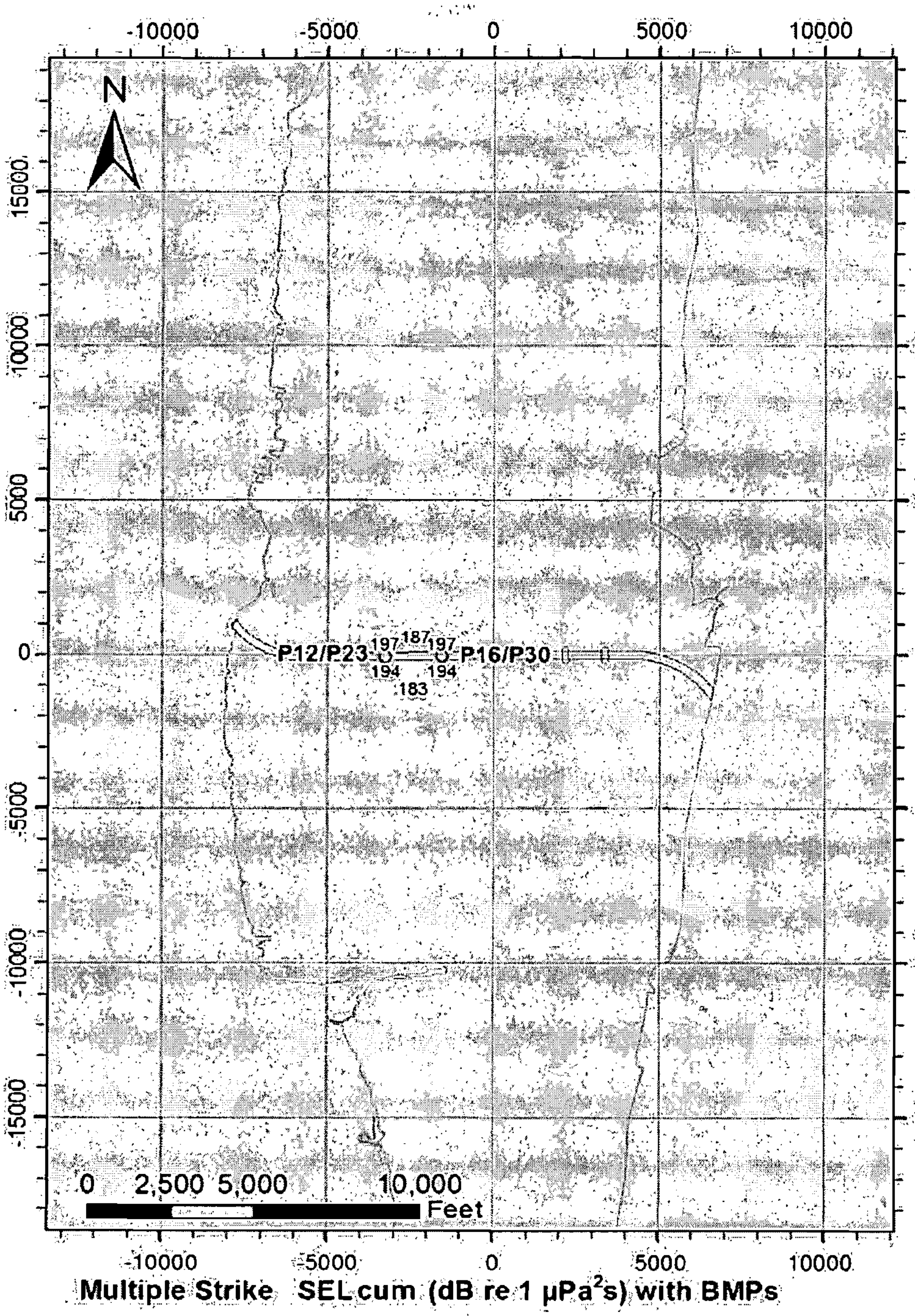

Figure 13. cSEL for installation of two 4-foot diameter piles simultaneously

8.3.2.4 Potential for Exposure to Underwater Noise

Shortnose and Atlantic sturgeon are likely to be present in the Tappan Zee Reach throughout the construction period. If an individual fish occurs within an area(s) ensonified over Peak 206 dB re 1 μPa for a single strike or 187 dB re 1 $\mu Pa^2 \cdot s$ for accumulated energy (SEL_{cum},) there is the potential for the onset of physiological effects. 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 is at least 1,000 and is the number of pile strikes needed to install the entire pile with an impact hammer.

Fish that are close to the piles during a pile driving operation could be exposed to single strike sound levels that are above the interim criteria defined above (e.g., 206 dB re 1 μPa peak), and there is a possibility of injury to these individual animals. However, methods have been tested that suggest, albeit with limited data, that fish move from the vicinity of pile driving prior to the onset of maximum strikes. For example, during the construction of the Woodrow Wilson Bridge over the Potomac River, there is evidence that tapping the pile with lower energy for the first few strikes may cause fish to move away from the piles before full operations begin (FHWA 2003). Reports from the Woodrow Wilson Bridge construction indicated that in some cases this kind of ramp-up procedure substantially decreased mortality; however, these findings were anecdotal and were not part of scientifically controlled studies. This "ramp up" or "soft start" method is also used to minimize potential exposure of marine animals to seismic and other noisy survey methods. The bridge replacement project will use a soft start method for all impact pile driving.

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

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

8.3.2.5.1 Exposure Potentially Resulting in Physiological Effects – Shortnose sturgeon

To estimate the potential number of shortnose sturgeon exposed to noise levels that could result in physiological effects (i.e., greater than 187 dB re 1 μPa^2-s cSEL, and greater than 206 dB re 1μPa peak), it is necessary to scale the revised gillnet encounter rates from a single gillnet sample to the area encompassed by the isopleth bounding the noise level under consideration. In the BA, FHWA presented tables that estimated the number of shortnose sturgeon that would be exposed to a cSEL of 187dB dB re 1 μPa^2-s (JASCO 2011). These tables are presented as Table 10 and 11 below.

Table 10. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using cSEL Criteria - Short Span Bridge Option

Year	Week	Pile Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs			
								Width of isopleth for 187-db SEL_{cum} (ft)	Number of gill nets (125-ft) to span width of isopleth	Sturgeon encounter rate per gill net (fish/hr)	Number of shortnose sturgeon potentially exposed to pile driving
1	40-44	10	50	4	1.55	2	38.75	7186	57	0.033	72.89
	45-48	6,8	20	7	1.11	2	11.1	5807	46	0.033	16.85
	49	6,8	8	7	1.11	2	4.44	6336	51	0.033	7.47
	50-51	4,8	20	6	1.14	2	11.4	7170	57	0.033	21.44
	52	4,8	10	6	1.14	2	5.7	6952	56	0.033	10.53
2	1	4,8	10	6	1.14	2	5.7	6952	56	0.033	10.53
	2	4,8	10	6	1.14	2	5.7	6735	54	0.033	10.16
	3-4	4,6,8	30	10	1.14	3	11.4	8418	67	0.033	25.21
	5	4,6,8	15	10	1.14	3	5.7	9324	75	0.033	14.11
	6	4,6,8	15	10	1.14	3	5.7	9253	74	0.033	13.92
	7	4,6,8	15	10	1.14	3	5.7	8312	66	0.033	12.41
	8-12	4,6,8	75	10	1.14	3	28.5	7732	62	0.033	58.31
	13	6,8	12	7	1.14	2	6.84	7732	62	0.033	13.99
	14-28	4,4	160	6	1.14	2	91.2	3490	28	0.033	84.27
	29-49	4	95	3	1.14	1	108.3	2024	16	0.033	57.18
	50-51	4,4,6	30	10	1.14	3	11.4	5581	45	0.033	16.93
	52	4,4,6	15	10	1.14	3	5.7	5036	40	0.033	7.52
3	1	4,4,6	15	10	1.14	3	5.7	5036	40	0.033	7.52
	2	4,4	10	6	1.14	2	5.7	3490	28	0.033	5.27
	3	4,4,6	15	10	1.14	3	5.7	4836	39	0.033	7.34
	4	4,4,6	16	10	1.14	3	6.08	4217	34	0.033	6.82
	5-10	4,4	65	6	1.14	2	37.05	3461	28	0.033	34.23

	11-12	4,4	22	6	1.14	2	12.54	3197	26	0.033	10.76
	13-17	4,4	53	6	1.14	2	30.21	3461	28	0.033	27.91
	18-20	4,4	30	6	1.14	2	17.1	3197	26	0.033	14.67
	21-25	4,4	55	6	1.14	2	31.35	3461	28	0.033	28.97
	26-27	4,4	20	6	1.14	2	11.4	3197	26	0.033	9.78
	28-33	4,4	60	6	1.14	2	34.2	3461	28	0.033	31.6
	34-35	4,4	20	6	1.14	2	11.4	3197	26	0.033	9.78
	36-41	4,4	60	6	1.14	2	34.2	3461	28	0.033	31.6
	42-52	4	60	3	1.14	1	68.4	2024	16	0.033	36.12
	1-14	4	70	3	1.14	1	79.8	2024	16	0.033	42.13
	15-16	6	12	4	0.33	1	3.96	2120	17	0.033	2.22
	17-18	6	6	4	0.33	1	1.98	2019	16	0.033	1.05
4	19	6	6	4	0.33	1	1.98	1821	15	0.033	0.98
	20	6	6	4	0.33	1	1.98	1624	13	0.033	0.85
	21	6	4	4	0.33	1	1.32	1440	12	0.033	0.52
	22-23	6	8	4	0.33	1	1.64	1060	8	0.033	0.43
5	50-52	4	15	3	1.14	1	17.1	2024	16	0.033	9.03
	1-5	4	25	3	1.14	1	28.5	2024	16	0.033	15.05
	6-7	6	12	4	0.33	1	3.96	2120	17	0.033	2.22
	9	6	6	4	0.33	1	1.98	2019	16	0.033	1.05
	10	6	6	4	0.33	1	1.98	1821	15	0.033	0.98
	11	6	6	4	0.33	1	1.98	1624	13	0.033	0.85
6	12	6	4	4	0.33	1	1.32	1440	12	0.033	0.52
	13	6	4	4	0.33	1	1.32	1280	10	0.033	0.44
	14	6	4	4	0.33	1	1.32	1060	8	0.033	0.35
	21	6	6	4	0.33	1	1.98	1346	11	0.033	0.72
	22	6	6	4	0.33	1	1.98	1020	8	0.033	0.52
Total Potential number of sturgeon within the 187-dB cSEL											**796**

Table 11. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using cSEL Criteria - Long Span Bridge Option

Year	Week	Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs			
								Width of isopleth for 187-db SEL_{cum} (ft)	Number of gill nets to span width of isopleth	Sturgeon encounter rate (fish/hr)	Number of shortnose sturgeon potentially affected by pile driving
1	40-44	10	50	4	1.55	2	38.75	7186	57	0.033	72.89
	45-48	6,8	20	7	1.11	2	11.1	5866	47	0.033	17.22
	49-50	6,8	16	7	1.11	2	8.88	6862	55	0.033	16.12
	51	6,8	12	7	1.11	2	6.66	7387	59	0.033	12.97
	52	6,8	14	7	1.11	2	7.77	7965	64	0.033	16.41
2	1	6,8	10	7	1.11	2	5.55	7767	62	0.033	11.36
	2-3	8	12	3	1.11	1	13.32	5648	45	0.033	19.78
	4-11	4,4	88	6	1.14	2	50.16	3458	28	0.033	46.35
	12-13	4,4	20	6	1.14	2	11.4	3910	31	0.033	11.66
	14-21	4,4	80	6	1.14	2	45.6	3458	28	0.033	42.13
	22-23	4,4	22	6	1.14	2	12.54	3910	31	0.033	12.83
	24-30	4,4	73	6	1.14	2	41.61	3458	28	0.033	38.45
	31-33	4	45	3	1.14	1	51.3	2064	17	0.033	28.78
	47-52	4,4	60	6	1.14	2	34.2	3712	30	0.033	33.86
3	1-4	4,4	40	6	1.14	2	22.8	3712	30	0.033	22.57
	5-18	4,4	160	6	1.14	2	91.2	3910	31	0.033	93.3
	19	4,4,6	21	10	1.14	3	7.98	3910	31	0.033	8.16
	20-21	4,6	34	7	1.14	2	19.38	4653	37	0.033	23.66
	22	4,6	22	7	1.14	2	12.54	4200	34	0.033	14.07
	23	4,6	16	7	1.14	2	9.12	3784	30	0.033	9.03
	24	4,6	11	7	1.14	2	6.27	3512	28	0.033	5.79
	25	4,6	11	7	1.14	2	6.27	3240	26	0.033	5.38

	26-33	4	40	3	1.14	1	45.6	2064	17	0.033	25.58
5	17-20	4	20	3	1.14	1	22.8	2064	17	0.033	12.79
	23	6	6	4	0.33	1	1.98	2282	18	0.033	1.18
	25	6	4	4	0.33	1	1.32	1395	11	0.033	0.48
	28	6	6	4	0.33	1	1.98	1759	14	0.033	0.91
	32	6	6	4	0.33	1	1.98	1469	12	0.033	0.78
	36	6	6	4	0.33	1	1.98	1178	9	0.033	0.59
Potential number of sturgeon within the 187-dB cSEL											**603**

While the estimated presented in Tables 10 and 11 is a reasonable estimate of the number of shortnose sturgeon that would be present in areas of this size for this amount of time, in order for this criteria to be relevant, we would need to expect that shortnose sturgeon would remain in that area for the entire duration of the pile driving activity. This is not a reasonable expectation because it does not take into account any behavioral response to noise stimulus. We expect sturgeon to respond behaviorally to noise stimulus and avoid areas above their noise tolerance. This behavioral response is expected to occur at noise levels of 150 dB re 1μPa RMS. 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. As evidenced in the figure above (Figure 12), the cSEL 187 dB re 1μPa 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 within the ensonified area for more than the time it would take them to swim out of the area (no more than a few minutes), we have determined that when assessing the potential for physiological impacts, the 206 dB re 1μPa peak criteria is more appropriate. This represents the instantaneous 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.

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

Data collected during the gillnet sampling study suggests that movement by shortnose sturgeon is strongly oriented into or with river currents. During the 2007-2008 gillnet study, shortnose sturgeon were collected with greater frequency in gillnets deployed across the river current vs. with the current. Based on these results, FHWA assumed that sturgeon moved in an upstream or downstream direction through the project area and at a constant rate and would thus be intercepted by gillnets spanning the width of the noise isopleth. FHWA also assumed that catch rates are proportional to shortnose sturgeon abundance, which is a central assumption of most fish-sampling gears, and that sturgeon were uniformly distributed throughout the Tappan Zee region. Under these assumptions, each gillnet would encounter shortnose sturgeon at the same rate allowing the estimates of sturgeon numbers to be scaled to the width of the isopleth. As an example, if the isopleth under consideration extended 2,500 feet that would be equivalent to 20 gill nets. At an encounter rate of 0.02 sturgeon per hour, the number of shortnose sturgeon that would pass through the ensonified area during the 4.6 hours required to conduct the test for one 4-ft pile would be: 0.03 shortnose sturgeon per hour * 20 nets*4.6 hrs = 1.84 shortnose sturgeon.

Tables 12 and 13 provide estimates of the number of shortnose sturgeon FHWA estimates to be exposed to the peak 206 dB re 1uPa level for the short and long span bridge replacement options. The analysis assumed a 10dB reduction in noise was achieved by the implementation of noise attenuation measures. This analysis incorporates the best estimate of pile driving scenarios throughout the construction period, including multiple piles being driven at one time. However, it is likely an overestimate because it assumes that every pile will be fully installed with impact hammers when in fact, most, if not all, piles will be installed at least partially with a vibratory hammer which would reduce the duration of impact pile driving and reduce the number of sturgeon exposed to the peak 206 dB re 1μPa noise level. Using the method explained above, FHWA estimates the number of shortnose sturgeon potentially exposed to underwater noise which may cause physiological effects (i.e., peak 206 dB re 1μPa) at 22 for the short span bridge option and 17 for the long span bridge option. However, this methodology adds up fractions of fish in its calculation. To be conservative, we have modified this estimate by rounding up any calculation resulting in a fraction of a fish exposed to a whole fish. Based on this modification to FHWA's estimate, we estimate that the total number of shortnose sturgeon that may be exposed to underwater noise which may cause physiological effects (i.e., peak 206 dB re 1μPa) would be 70 or 43 fish for the short and long span bridge replacement options, respectively.

Table 12. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using peak Criteria - Short Span Bridge Option

Year	Week	Pile Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs				
								Width of isopleth for 206-db peak SPL (ft)	Number of gill nets (125-ft) to span width of isopleth	Sturgeon encounter rate per gill net (fish/hr)	Number of shortnose sturgeon potentially exposed to pile driving	Number of shortnose sturgeon rounded up to whole fish
1	40-44	10	50	4	1.55	2	38.75	1200	10	0.033	12.28	13
	45-48	6,8	20	7	1.11	2	11.1	370	3	0.033	1.08	2
	49	6,8	8	7	1.11	2	4.44	370	3	0.033	0.43	1
	50-51	4,8	20	6	1.14	2	11.4	320	3	0.033	0.96	1
	52	4,8	10	6	1.14	2	5.7	320	3	0.033	0.48	1
2	1	4,8	10	6	1.14	2	5.7	320	3	0.033	0.48	1
	2	4,8	10	6	1.14	2	5.7	320	3	0.033	0.48	1
	3-4	4,6,8	30	10	1.14	3	11.4	440	4	0.033	1.32	2
	5	4,6,8	15	10	1.14	3	5.7	440	4	0.033	0.66	1
	6	4,6,8	15	10	1.14	3	5.7	440	4	0.033	0.66	1
	7	4,6,8	15	10	1.14	3	5.7	440	4	0.033	0.66	1
	8-12	4,6,8	75	10	1.14	3	28.5	440	4	0.033	3.31	4
	13	6,8	12	7	1.14	2	6.84	370	3	0.033	0.67	1
	14-28	4,4	160	6	1.14	2	91.2	70	1	0.033	1.69	2
	29-49	4	95	3	1.14	1	108.3	70	1	0.033	2.00	2
	50-51	4,4,6	30	10	1.14	3	11.4	190	2	0.033	0.57	1
	52	4,4,6	15	10	1.14	3	5.7	190	2	0.033	0.29	1
3	1	4,4,6	15	10	1.14	3	5.7	190	2	0.033	0.29	1
	2	4,4	10	6	1.14	2	5.7	70	1	0.033	0.11	1
	3	4,4,6	15	10	1.14	3	5.7	190	2	0.033	0.29	1
	4	4,4,6	16	10	1.14	3	6.08	190	2	0.033	0.30	1
	5-10	4,4	65	6	1.14	2	37.05	70	1	0.033	0.68	1
	11-12	4,4	22	6	1.14	2	12.54	70	1	0.033	0.23	1

	13-17	4,4	53	6	1.14	2	30.21	70	1	0.033	0.56	1
	18-20	4,4	30	6	1.14	2	17.1	70	1	0.033	0.32	1
	21-25	4,4	55	6	1.14	2	31.35	70	1	0.033	0.58	1
	26-27	4,4	20	6	1.14	2	11.4	70	1	0.033	0.21	1
	28-33	4,4	60	6	1.14	2	34.2	70	1	0.033	0.63	1
	34-35	4,4	20	6	1.14	2	11.4	70	1	0.033	0.21	1
	36-41	4,4	60	6	1.14	2	34.2	70	1	0.033	0.63	1
	42-52	4	60	3	1.14	1	68.4	70	1	0.033	1.26	2
4	1-14	4	70	3	1.14	1	79.8	70	1	0.033	1.47	2
	15-16	6	12	4	0.33	1	3.96	120	1	0.033	0.13	1
	17-18	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	19	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	20	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	21	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	22-23	6	8	4	0.33	1	1.64	120	1	0.033	0.05	1
5	50-52	4	15	3	1.14	1	17.1	70	1	0.033	0.32	1
6	1-5	4	25	3	1.14	1	28.5	70	1	0.033	0.53	1
	6-7	6	12	4	0.33	1	3.96	120	1	0.033	0.13	1
	9	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	10	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	11	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	12	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	13	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	14	6	4	4	0.33	1	1.32	120	1	0.033	0.04	1
	21	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	22	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
Total Potential number of sturgeon within the 206-dB peak SPL												**70**

Table 13. Number of Shortnose Sturgeon Potentially Affected by Pile Driving using peak Criteria - Long Span Bridge Option

Year	Week	Diameter (feet)	Number of piles	Number of piles driven/day	Pile driving time (hours/pile)	Number of concurrently driven piles	Estimated pile driving time (hours)	With 10 dB BMPs				
								Width of isopleth for 206-db peak SPL (ft)	Number of gill nets to span width of isopleth	Sturgeon encounter rate (fish/hr)	Number of shortnose sturgeon potentially affected by pile driving	Number of shortnose sturgeon rounded up to whole fish
1	40-44	10	50	4	1.55	2	38.75	1200	10	0.033	12.28	13
	45-48	6,8	20	7	1.11	2	11.1	370	3	0.033	1.08	2
	49-50	6,8	16	7	1.11	2	8.88	370	3	0.033	0.87	1
	51	6,8	12	7	1.11	2	6.66	370	3	0.033	0.65	1
	52	6,8	14	7	1.11	2	7.77	370	3	0.033	0.76	1
2	1	6,8	10	7	1.11	2	5.55	370	3	0.033	0.54	1
	2-3	8	12	3	1.11	1	13.32	250	2	0.033	0.88	1
	4-11	4,4	88	6	1.14	2	50.16	70	1	0.033	0.93	1
	12-13	4,4	20	6	1.14	2	11.4	70	1	0.033	0.21	1
	14-21	4,4	80	6	1.14	2	45.6	70	1	0.033	0.84	1
	22-23	4,4	22	6	1.14	2	12.54	70	1	0.033	0.23	1
	24-30	4,4	73	6	1.14	2	41.61	70	1	0.033	0.77	1
	31-33	4	45	3	1.14	1	51.3	70	1	0.033	0.95	1
	47-52	4,4	60	6	1.14	2	34.2	70	1	0.033	0.63	1
3	1-4	4,4	40	6	1.14	2	22.8	70	1	0.033	0.42	1
	5-18	4,4	160	6	1.14	2	91.2	70	1	0.033	1.69	2
	19	4,4,6	21	10	1.14	3	7.98	190	2	0.033	0.40	1
	20-21	4,6	34	7	1.14	2	19.38	190	2	0.033	0.97	1
	22	4,6	22	7	1.14	2	12.54	190	2	0.033	0.63	1

	23	4,6	16	7	1.14	2	9.12	190	2	0.033	0.46	1
	24	4,6	11	7	1.14	2	6.27	190	2	0.033	0.31	1
	25	4,6	11	7	1.14	2	6.27	190	2	0.033	0.31	1
	26-33	4	40	3	1.14	1	45.6	70	1	0.033	0.84	1
5	17-20	4	20	3	1.14	1	22.8	70	1	0.033	0.42	1
	23	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	25	6	4	4	0.33	1	1.32	70	1	0.033	0.02	1
	28	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	32	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
	36	6	6	4	0.33	1	1.98	120	1	0.033	0.06	1
Potential number of sturgeon within the 206-dB peak SPL												**43**

FHWA indicates in the BA that physiological effects are likely to be limited to minor injuries. We agree with this assessment as it is likely that sturgeon will begin to avoid the ensonified area prior to getting close enough to experience noise levels that could result in major injuries or mortality. Minor injuries, such as burst capillaries near fins, could be experienced. However, we expect that fish would fully recover from these types of injuries without any effect on their potential survival or future fitness. Any shortnose sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience major injuries or mortality. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 25-40% of its total energy. This is expected to cause any sturgeon nearby the pile at the time that pile driving begins to move further away and reduce the potential for exposure to noise levels that would be potentially mortal. While sturgeon in the area would be temporarily exposed to noise levels that are likely to result in physiological effects, the short term exposure is likely to result in these injuries being minor. Shortnose sturgeon are known to avoid areas with conditions that would cause physiological effects (e.g., low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that a shortnose sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique and the expected behavioral response of moving away from the piles being installed, this situation is likely to be very rare; however, given the number of piles to be installed and the duration over which pile driving will occur, it is possible that this unexpected event could occur. However, because we expect it to be very rare, we expect that no more than one shortnose sturgeon is likely to suffer major injury or die as a result of exposure to pile driving noise. Effects on behavior are discussed below. It is important to note that during the PIDP, where seven test piles were installed with impact hammers, FHWA conducted monitoring designed to detect any stunned, injured or dead sturgeon during and following pile driving. No sturgeon were observed during this monitoring. This supports the conclusions reached here, that injury and mortality will be rare.

8.3.2.5.3 Exposure Potentially Resulting in Physiological Effects – Atlantic sturgeon

No Atlantic sturgeon were captured during the one year gillnet study which consisted of 476 collections over 679 hours; this is likely due to the relatively small mesh size fished which would likely preclude capture of large subadults and adults as well as the relatively low abundance of Atlantic sturgeon in the area. Other available information, including the Long River surveys and tagging and tracking studies conducted by NYDEC and other researchers indicates that juvenile, subadult and adult Atlantic sturgeon are likely to occur in the Tappan Zee region. Population estimates of Hudson River Atlantic sturgeon from the literature and interaction rates in Fall Shoals Program from 2000-2009 of shortnose vs. Atlantic sturgeon suggest that the number of Atlantic sturgeon in the action area would be considerably lower than numbers of shortnose sturgeon.

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

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

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

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

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

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

Therefore, the lower bounds were calculated as:

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

where,
Sturgeon_{max} = the maximum weekly number of sturgeon within the isopleths, and
SC_{max} = the maximum weekly average standing crop of the Hudson River.

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

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

Therefore, the upper bounds were calculated as:

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

where,
Sturgeon_{weekly} = the weekly number of sturgeon within the isopleths, and
n_{weeks} = the number of weeks of pile driving during construction.

Using this methodology, FHWA determined that no more than one juvenile Atlantic sturgeon would be exposed to noise of a peak 206 dB re 1uPa. The same methodology was also used to determine the number of Atlantic sturgeon that could be exposed to the cSEL of 187 dB re 1uPa; however, as explained above for shortnose sturgeon, use of this criteria is not appropriate in this case for determining the potential for physiological effects. Using the same method, FHWA estimates that no more than 1 "juvenile" Atlantic sturgeon would be exposed to the 206 dB re 1μPa^2•s peak SEL ensonified area during the course of the construction period. However, even when considering the upper bounds of this model, while the model assumes an "open system" with sturgeon moving throughout the River, it does not appear that the model accounts for the potential for Atlantic sturgeon of this size class to leave the river or to enter the river from other systems. Additionally, we cannot validate the assumptions made regarding gear selectivity for shortnose vs. Atlantic sturgeon. For example, we do not know if there are behavioral differences that make it or more or less likely to capture a shortnose sturgeon versus an Atlantic sturgeon of the same size in the same gear. Because of these factors, and because we cannot validate other model parameters, it is difficult to determine the validity of these estimates.

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

8.3.2.5.4 Estimate of the Number of Atlantic sturgeon that will experience Physiological Effects

While we cannot rely on the estimates provided by FHWA for the number of juvenile or adult Atlantic sturgeon likely to be exposed to noise levels of 206 dB re 1 μPa peak, because we know that there are fewer Atlantic sturgeon in the project area than shortnose sturgeon and we have an estimate of the number of shortnose sturgeon likely to be exposed to noise levels of 206 dB re 1 μPa peak, we can produce an estimate of the maximum number of Atlantic sturgeon we expected to be exposed to noise levels of 206 dB re 1 μPa peak. We do not expect that Atlantic sturgeon use this area of the river more frequently than shortnose sturgeon (i.e., we do not expect more Atlantic sturgeon in the area than shortnose sturgeon) and we expect that because of similar morphology, we expect their hearing and behavioral responses to sound to be similar. Based on the calculations for shortnose sturgeon, we anticipate that the number of Atlantic sturgeon that may be exposed to noise levels of 206 dB re 1 μPa peak and therefore, the number that may experience physiological effects, would be less than 70 or 43 for the short and long span bridge replacement options, respectively.

Pile driving will occur year round; therefore the Atlantic sturgeon exposed to pile driving noise are expected to be juveniles, subadults and adults. However, because the potential for mortal injury due to noise exposure decreases with fish size, and because adult Atlantic sturgeon are very large (at least 1,500 mm (approximately 5 feet in length), it is unlikely that the one fish that we expect to experience serious injury or mortality would be an adult. Based on the mixed-stock analysis, we expect that, for the short span bridge option, of the 70 Atlantic sturgeon that could experience physiological effects, 64 would be from the New York Bight DPS (juveniles, subadults or adults), four from the Gulf of Maine DPS (subadults or adults), and two from the Chesapeake Bay DPS (subadults or adults). For the long span bridge option, based on the mixed-stock analysis, we expect that of the 43 Atlantic sturgeon that could experience physiological effects, 39 would be from the New York Bight DPS, three from the Gulf of Maine DPS, and one from the Chesapeake Bay DPS. It is most likely that the one fish that may be mortally injured or killed would originate from the New York Bight DPS. However, because Atlantic sturgeon from the Chesapeake Bay and Gulf of Maine DPSs are also present in the area, it is possible that the fish that dies could originate from any of the three DPSs.

Like shortnose sturgeon, we anticipate that physiological effects to individual Atlantic sturgeon are likely to be limited to minor injuries as sturgeon are expected to begin to avoid the ensonified area prior to getting close enough to experience noise levels that could result in major injuries or mortality. Minor injuries, such as burst capillaries near fins, could be experienced. However, we expect that fish would fully recover from these types of injuries without any effect on their potential survival or future fitness. Any Atlantic sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience major injuries or mortality. This will be facilitated by the use of a "soft start" or system of "warning strikes" where the pile driving will begin at only 25-40% of its total energy. This is expected to cause any sturgeon nearby the pile at the time that pile driving begins to move further away and reduce the potential for exposure to noise levels that would be potentially mortal. While sturgeon in the area would be temporarily exposed to noise levels that are likely to result in physiological effects, the short term exposure is likely to result in these injuries being minor. Atlantic sturgeon are known to avoid areas with conditions that would cause physiological effects (e.g., low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that an Atlantic sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique and the expected behavioral response of moving away from the piles being installed, this situation is likely to be very rare; however, given the number of piles to be installed and the duration over which pile driving will occur, it is possible that this unexpected event could occur. However, because we expect it to be very rare, we expect that no more than one Atlantic sturgeon is likely to suffer major injury or die as a result of exposure to pile driving noise. Effects on behavior are discussed below.

8.3.5.2.4 Exposure Potentially Resulting in Behavioral Effects

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

When considering the potential for behavioral effects, we need to consider the geographic and temporal scope of any impacted area. For this analysis, we consider the area within the river where noise levels greater than 150 dB re 1 μPa will be experienced and the duration of time that those underwater noise levels could be experienced (for example, see Figure 14).

Depending on the pile being driven, the 150 dB re 1 μPa RMS isopleth would extend from 2,500 to 19,000 feet in a north-south direction and 2,500 to 9,000 feet in an east-west direction. The Hudson

River at the project site is approximately 3 miles wide (15,840 feet). Even in the worst case, during the installation of multiple 10 foot piles, a continuous east-west stretch of at least 1,500 feet would have noise levels less than 150 dB re 1 μPa. Assuming the worst case behaviorally, that sturgeon would avoid an area with underwater noise greater than 150 dB re 1 μPa, there would still be a significant area where fish could pass through unimpeded. Additionally, the maximum amount of time when pile driving of 8 and 10 feet piles within Zone C (water depths 18-45 feet; nearest to the channel where sturgeon are expected to be migrating) will occur is for 5 hours a day from April – August and no more than 12 hours a day for all other piles. Pile driving will not occur on the weekends. Over the course of the five year project, pile driving will be ongoing for approximately 7% of the time; thus, the time period when sturgeon would expect to react behaviorally to pile driving noise is relatively small. In the worst case, fish would avoid the ensonfied area for the entirety of the pile driving period; however, pile driving will never occur for more than 12 hours a day and the 150 dB re 1uPa RMS isopleth never extends across the entirety of the river.

C.2.4. 10' pile size

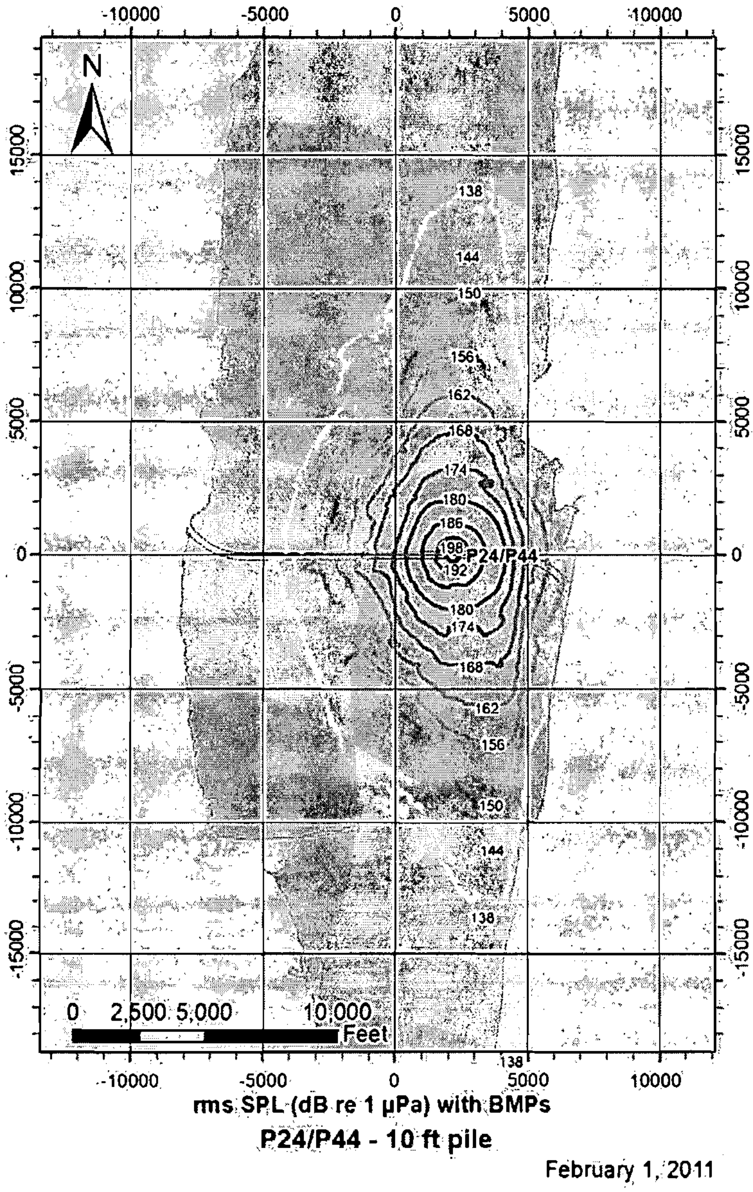

Figure 14. Illustration of rms SPL with 10 dB noise reduction BMPs.

After establishing the potential for exposure, we consider what impact this would have on individual shortnose and Atlantic sturgeon. Shortnose and Atlantic sturgeon in the action area are likely to be migrating through the area and may forage opportunistically while migrating. The action area is not known to be an overwintering area or a spawning or nursery site. An individual migrating up or downstream through the action area may change course to avoid the ensonified area; however, given that there will always be a portion of the river width where noise levels would be less than 150 dB re 1 μPa RMS and that any changes in movements would be limited to a 5-12 hour period when pile driving would be occurring, 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 limit on the duration of pile driving during the time of year when prespawning adult Atlantic sturgeon would be moving through the action area (April – August) to only five hours per day, make it extremely unlikely that an adult Atlantic sturgeon would not successfully migrate through the action area. The largest ensonified area occurs when the 10-foot piles are being driven. The time required to drive all 50 of the 10-ft piles would be approximately 39 hours or 1.1% of the time in which spawning adults occupy the river (i.e., April – August); thus, the period of time when pile driving will be ongoing that overlaps with the period when adult Atlantic sturgeon would be moving through the project area is extremely small. 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.

8.3.2.5.6 Summary of effects of noise exposure

In summary, we anticipate that individual sturgeon present in the action area during the time that impact pile driving occurs may make minor adjustments to their behaviors to avoid the ensonified areas. For the reasons outlined above, we expect the effects of any changes in behavior to be insignificant and discountable. We do, however, expect that any sturgeon that do not avoid the ensonified area will be exposed to underwater noise levels that could result in physiological impacts. However, with rare exception, we anticipate that the effects of this exposure will be limited to minor injuries from which all affected individuals will fully recover without any future reduction in survival or fitness. We anticipate that the number of sturgeon that may experience physiological impacts would be limited to 70 or fewer shortnose sturgeon and 70 or fewer than Atlantic sturgeon for the short span bridge option and 43 or fewer shortnose sturgeon and 43 or fewer Atlantic sturgeon for the long span bridge option. We anticipate the serious injury or mortality of no more than one shortnose sturgeon and no more than one Atlantic sturgeon for either bridge option.

8.4 Impacts of Vessel Traffic

8.4.1 Potential for Vessel Strike

There is limited information on the effects of vessel operations on shortnose sturgeon. It is generally assumed that as shortnose sturgeon are benthic species, that their movements are limited to the bottom of the water column and that vessels operating with sufficient navigational clearance would not pose a risk of ship strike. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to Atlantic sturgeon that are larger and for which ship strikes have been documented more frequently. However, anecdotal evidence suggests that shortnose sturgeon at least occasionally interact with vessels, as evidence by wounds that appear to be caused by propellers. There has been only one confirmed incidence of a ship strike on a shortnose sturgeon and two suspected ship strike mortalities. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20 foot) boat transiting a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. The other two suspected ship strike mortalities occurred in the Delaware River. On June 8, 2008, a shortnose was collected near Philadelphia. The fish was necropsied and found to have suffered from blunt force trauma; though there was no ability to confirm whether the source of the trauma resulted from a vessel interaction. Lastly, on November 28, 2007, a shortnose sturgeon was collected on the trash racks of the Salem Nuclear Generating Facility. The fish was not necropsied, however, a pattern of lacerations on the carcass suggested a possible vessel interaction; however, it could not be determined if these wounds were inflicted prior to or after the fish's death.

Aside from these incidents, no information on the characteristics of vessels that are most likely to interact with shortnose sturgeon is available and there is no information on the rate of interactions. However, assuming that the likelihood of interactions increases with the number of vessels present in an area, NMFS has considered the likelihood that an increase in ship traffic associated with the bridge construction project would increase the risk of interactions between shortnose sturgeon and ships in the Hudson River generally.

As noted in the 2007 Status Review and the final listing rule, in certain geographic areas vessel strikes have been identified as a threat to Atlantic sturgeon. While the exact number of Atlantic sturgeon killed as a result of being struck by boat hulls or propellers is unknown, it is an area of concern in the Delaware and James rivers. Brown and Murphy (2010) examined twenty-eight dead Atlantic sturgeon observed in the Delaware River from 2005-2008. Fifty-percent of the mortalities resulted from apparent vessel strikes and 71% of these (10 of 14) had injuries consistent with being struck by a large vessel (Brown and Murphy 2010). Eight of the fourteen vessel struck sturgeon were adult-sized fish (Brown and Murphy 2010). Given the time of year in which the fish were observed (predominantly May through July; Brown and Murphy 2010), it is likely that many of the adults were migrating through the river to the spawning grounds.

The factors relevant to determining the risk to Atlantic sturgeon from vessel strikes are currently unknown, but they may be related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of Atlantic sturgeon in the area (e.g., foraging, migrating, etc.). Large vessels have been implicated because of their deep draft [up to 12.2-13.7 m (40-45 feet)] relative to smaller vessels [<4.5 m (15 feet)], which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Smaller vessels and those with relatively shallow drafts provide more clearance with the river bottom and reduce the probability of vessel-strikes. Because the construction vessels (tug boats, barge crane, hopper scow) have relatively shallow drafts, the chances of vessel-related mortalities are expected to be low. The maximum allowable draft of any of the construction vessels will be 3.2 to 3.6 m

(10.5 to 12ft), however, under typical operating conditions, vessels will draft 2.1 to 2.4 m (7 to 8 ft), providing 1.8-2.4 m (6-7 ft) of clearance with the bottom at all times. Maximum allowable drafts will only occur under full load and while turning. Under working conditions, stationary tug boats will maintain 1.8 m (6 ft) clearance between the prop and the bottom and will only infrequently approach 1.1 m (3.5 ft) clearance.

The increased vessel traffic associated with the Tappan Zee Bridge replacement is not expected to result in direct interactions with sturgeon, because the life stages present in this reach of the river tend to occupy the bottom meter of the water column over fine-grained substrates in the deepest water areas and would be below the draft of the vessels involved.

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

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

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

8.4.2 Noise Associated with Vessel Movements

Another potential impact associated with increased vessel traffic is radiated noise. Fish in the action area experience an acoustic environment that is generally highly energetic under "normal" conditions. The sound levels lower in the estuary result from the high volume of commercial shipping traffic within the tidal Hudson and New York Harbor, and these do not appear to affect the behavior or migration of sturgeon that bypass this very noisy region each year. While noise levels resulting from shipping in the estuary are not known, it is possible to get a first approximation based upon results of other studies which indicate that sound levels due to radiated vessel noise would be below thresholds for the onset of injury to fish (Wursig *et al.* 2002). Furthermore, because of the comparatively poor hearing ability of sturgeon (Lovell *et al.* 2005; Meyer *et al.* 2010, 2012), it is likely that many of the sounds which are audible to most species, are not audible to sturgeon.

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

8.5 Loss of Benthic Resources

Dredging will remove benthic organisms that are immobile or have limited mobility from the access channel. Dredging will remove benthic macroinvertebrates, including oyster beds. Approximately 0.67 to 0.71 km^2 (165 to 175 acres) of bottom habitat, including about 0.0004 km^2 (0.11 acres) of NYSDEC littoral zone tidal wetland and 0.65-0.69 km^2 (160-170 acres) of open water benthic habitat, would be dredged over the four year period. In addition, the trench would be armored following dredging and the benthic habitat within the dredge zone which was primarily soft sediment would be changed to a substrate of sand and gravel. Since armoring would occur up to 6.1 m (20 feet) of the side slope, total acreage of hard bottom would be approximately 0.63 to 0.67 km^2 (155 to 165 acres). The materials would not be removed after the project completion, since they would become fully buried by the gradual deposition of river sediments over time once construction was completed. Modeling indicated that the rate of this transformation would begin at approximately one foot per year, likely decreasing as the bed nears it natural pre-dredged elevation. Other studies indicate that deposition rates in this portion of the river can vary widely depending on seasonal events such as storm events and freshets, and may be somewhat slower than predicted by the modeling. It is expected that the sand and gravel will, over time, naturally return to soft sediment as new material is deposited in the access channel area. Since much of the benthic community exists in the upper 10 cm of sediment as demonstrated from benthic samples taken throughout the Hudson River (Versar 2003), benthic recovery should begin quickly, particularly in the soft bottom sediments.

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

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

In summary, with the exception of up to 13 acres of oyster beds that may be permanently lost where access channels are dredged, there would be a temporary loss of habitat that could affect sturgeon that use the dredged area for foraging. These effects would occur as a result of a localized reduction in benthic fauna. However, the dredging footprint represents a very small percentage of the soft bottom habitat of the Tappan Zee region (1.2%) and the Hudson River Estuary (0.2%). Thus, the temporary reduction of benthic fauna within the dredged area would not substantially reduce foraging opportunities for the river's sturgeon populations. As noted above, once in-water activities are completed, the dredged channels would be restored over time to their original elevations and the river's benthic community would recolonize those areas. As the area returns to soft sediment and is recolonized by benthic invertebrates, sturgeon will regain any lost foraging habitat.

Dredging would remove about 0.05 km^2 (13 acres) of oyster beds, some or all of which may be permanently lost due to dredging and armoring of the bottom. Oyster beds were mapped using side scan sonar imagery approximately two miles north and south of the existing bridge from depths of 2.4 to 9.1 m (8 to 30 feet). Seven potential oyster beds were identified south of the bridge and six potential beds to the north (see Appendix E-3 of the DEIS for a description of each of the beds). During the subsequent grab sample program all identified oyster beds except one were confirmed to contain at least some live organisms with beds exhibiting differences in terms of oyster density, amount of shell hash, gravel, or sandstone fragments, etc. It is likely that mitigation for loss of the oyster beds will be implemented; however, no details on the extent or likely success of oyster mitigation requirements (e.g. creation of new oyster beds, augmentation of existing beds) are available at this time. Neither Atlantic or shortnose sturgeon are known to feed on oysters (see Haley *et al.* 1996 and Haley 1999 for discussion of diets in the Hudson River). Studies on foraging Atlantic sturgeon indicate that their benthic invertebrate prey are typically found in fine-grained silt-clay sediments (Hatin *et al.* 2002, 2007). Studies carried out on foraging Atlantic and shortnose sturgeon in the Hudson River indicate that significantly more shortnose and Atlantic sturgeon were collected over silt substrate as compared to sand or gravel. Ninety-two percent of collected shortnose were on silt substrate with none on gravel substrate. Similarly, 96% of Atlantic sturgeon were collected over silt substrate, with none collected over gravel substrate. Based on this, the loss of hard bottom substrate provided by the oyster beds is not likely to affect foraging shortnose sturgeon.

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

8.6 Effects of Increased Turbidity and Suspended Sediment

Several activities will result in increases in turbidity and/or suspended sediment including dredging, depositing sand and gravel to armor the access channel and the installation of cofferdams and piles. The background concentration of TSS in the vicinity of the TZB generally varies between 15 and 50 mg/L throughout the year, but reaches much higher levels as a consequence of storm events, such as Hurricane Irene in 2011 when the extremely high turbidity episode lasted several weeks.

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

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

Monitoring of twelve mechanical dredge operations in the Delaware River (Burton 1993) in 1992 indicated that sediment plumes fully dissipated by 3,300-feet from the dredge area. The Delaware River study also indicated that mechanical dredging does not alter turbidity or dissolved oxygen to a biologically significant degree and analysis did not reveal a consistent trend of higher turbidity and lower dissolved oxygen within the sediment plume.

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

Hydrodynamic modeling conducted for the Tappan Zee project and discussed in the DEIS (FHWA 2012) indicated that on flood and ebb tides, concentrations of suspended sediment 10 mg/L above ambient conditions may extend in a relatively thin band approximately 1,000 to 2,000 feet from the dredges, while concentrations of 5 mg/L may extend a greater distance. These changes are considered well within the natural variation that has been observed within the Hudson River. For example, during the sampling conducted for the project, TSS concentrations ranged from 13 to 111 mg/L. Data recorded at Poughkeepsie indicated that during higher freshwater flow periods the difference between suspended sediment concentrations can vary by 20 to 40 mg/L.

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

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

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

There will also be increases in suspended sediment during cofferdam construction and during pile driving. Available information indicates that turbidity levels during these activities will be about 30% and 40% of average resuspension levels experienced during dredging, respectively (FHWA 2012); therefore, increases in suspended sediment are expected to be less than 50 mg/l. Concentrations of total suspended sediment resulting from pile driving would be elevated approximately 5 to 10 mg/L above background within a few hundred feet of the pile being driven (FHWA 2011b -pDEIS). Increases in concentrations of total suspended sediment resulting from construction vessel movement are projected to be less than 5 mg/L.

Studies of the effects of turbid waters on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993). The studies reviewed by Burton demonstrated lethal effects to fish at concentrations of 580mg/L to 700,000mg/L depending on species. Sublethal effects have been observed at substantially lower turbidity levels. For example, prey consumption was significantly lower for striped bass larvae tested at concentrations of 200 and 500 mg/L compared to larvae exposed to 0 and 75 mg/L (Breitburg 1988 in Burton 1993). Studies with striped bass adults showed that pre-spawners did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Moiser 1976 and Combs 1979 in Burton 1993). The Normandeau 2001 report identified five species in the Kennebec River for which TSS toxicity information was available. The most sensitive species reported was the four spine stickleback which demonstrated less than 1% mortality after exposure to TSS levels of 100mg/L for 24 hours. Striped bass showed some adverse blood chemistry effects after 8 hours of exposure to TSS levels of 336mg/L. While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, shortnose and Atlantic sturgeon juveniles and adults are often documented in turbid water and Dadswell (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.

8.7 Contaminant Exposure

Resuspension of sediments by dredging or pile installation may release contaminants into the water column from either sediment pore water or from contaminants that partition from the sediment's solid phase. However, due to the nature of sediments in the bridge vicinity (i.e., low levels of contamination), and the limited areal extent of any sediment plume expected to be generated, any mobilization of contaminated sediments is expected to be minor (FHWA 2012). Contaminants may be released from the pore water of the sediments, on the resuspended sediments or may dissolve into the water. Although limited SVOCs, pesticide, PCBs and TCDD were detected in the sediments in the area of the bridge, FHWA has concluded that because of the low detection rates and low concentrations of these contaminants, there would be no measurable increase in the level of these contaminants in the area.

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

Water quality criteria are developed by EPA for protection of aquatic life. Both acute (short term exposure) and chronic (long term exposure) water quality criteria are developed by EPA based on toxicity data for plants and animals. Often, both saltwater and freshwater criteria are developed, based on the suite of species likely to occur in the freshwater or saltwater environment. For aquatic life, the national recommended toxics criteria are derived using a methodology published in *Guidelines for Deriving Numeric National Water Quality Criteria for the Protection of Aquatic Organisms and Their*

Uses. Under these guidelines, criteria are developed from data quantifying the sensitivity of species to toxic compounds in controlled chronic and acute toxicity studies. The final recommended criteria are based on multiple species and toxicity tests. The groups of organisms are selected so that the diversity and sensitivities of a broad range of aquatic life are represented in the criteria values. To develop a valid criterion, toxicity data must be available for at least one species in each of eight families of aquatic organisms. The eight taxa required are as follows: (1) salmonid (e.g., trout, salmon); (2) a fish other than a salmonid (e.g., bass, fathead minnow); (3) chordata (e.g., salamander, frog); (4) planktonic crustacean (e.g., daphnia); (5) benthic crustacean (e.g., crayfish); (6) insect (e.g., stonefly, mayfly); (7) rotifer, annelid (worm), or mollusk (e.g., mussel, snail); and, (8) a second insect or mollusk not already represented. Where toxicity data are available for multiple life stages of the same species (e.g., eggs, juveniles, and adults), the procedure requires that the data from the most sensitive life stage be used for that species.

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

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

Table 14. 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

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.

8.8 Bridge Demolition

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

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

8.9 Operation of new bridge

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

8.9.1 Shading

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

Because the elevations of the existing Tappan Zee Bridge and the new bridge are not consistent over the length of the structure, the height-to-width ratio of the bridge varies along its length. The two spans of the new bridge would be separated by a gap up to 70 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, Short and Long Span Options, are generally much higher, ranging from 0.21 near the shoreline to 1.07, with the ratios for the Long Span Option being slightly less because the height for this approach option is lower. 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 with the Long Span Option for the new bridge having the lower ratios.

The separation between the decks of the two spans (i.e., 70 feet at the main span and then decreasing toward the shorelines) allows light to penetrate between the two structures. This represents the best case analysis. Under this case, the new bridge would result in a lower potential for shading of aquatic habitat compared to the existing bridge, particularly along the causeway (western approach to the main span). Even under the worst case, which assumes no separation between the spans of the new bridge and which would conservatively result in a halving of the height-to-width ratios presented above, the new bridge would still result in greater ratios (i.e., less shading) than the existing bridge for the western approach, but may result in more shading than the existing bridge for the eastern approach. Overall, the height-to-width ratios indicate that even if the new bridge was treated as a single structure, with no separation between the spans, there would be a decrease in the potential for shading impacts to aquatic resources along much of the bridge route. The approximately 99,153-square foot permanent platform at the Rockland Bridge Landing would result in additional aquatic habitat affected by shading. Considering the extensive area of aquatic habitat not affected by shading within the area, any effects to sturgeon from the additional shading caused by the permanent platform and by the bridge are extremely unlikely.

8.9.2 Habitat Alteration

Because the existing bridge will be removed and the new bridge piers will have a smaller footprint, the only net change in available benthic habitat will be from the permanent platform to be located along the Rockland County shoreline. The DEIS indicated that construction of the permanent platform along the Rockland County shoreline would result in the loss of 2.16 acres of benthic habitat. Revisions to the construction plans since the DEIS was drafted have reduced the acreage of habitat loss due to the permanent platform to 0.12 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.

8.9.3 Stormwater Runoff

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

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

8.9.4 Climate Change Related Effects

In the DEIS, 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 DEIS, 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, with emissions from the Short Span Option approximately 12 percent higher than the Long Span Option. 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 sections 5.0 and 7.0 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 100 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.

9.0 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 DEIS - Champlain-Hudson Power Express and dredging at the US Gypsum and American Sugar facilities – will require authorization by the US Army Corps of Engineers, therefore they are considered future

Federal actions and do not meet the definition of "cumulative effects" under the ESA and are not considered here.

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

State Water Fisheries - Future recreational and commercial fishing activities in state waters may take shortnose and Atlantic sturgeon. In the past, it was estimated that up to 100 shortnose sturgeon were captured in shad fisheries in the Hudson River each year, with an unknown mortality rate. Atlantic sturgeon were also incidentally captured in NY state shad fisheries. In 2009, NY State closed the shad fishery indefinitely. That state action is considered to benefit both sturgeon species. Should the shad fishery reopen, shortnose and Atlantic sturgeon would be exposed to the risk of interactions with this fishery. However, NMFS has no indication that reopening the fishery is reasonably certain to occur.

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

State PDES Permits – The states of New York and New Jersey have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Some of the facilities that operate pursuant to these permits are included in the Environmental Baseline (e.g., Indian Point). Other permitees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the SPDES permits. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the status of the species/environmental baseline section.

10.0 INTEGRATION AND SYNTHESIS OF EFFECTS

Dredging to be carried out during the bridge replacement project is expected to result in the capture of three shortnose sturgeon and three Atlantic sturgeon, with the injury or mortality of one of these shortnose sturgeon and one of these Atlantic sturgeon. The number of sturgeon exposed to underwater noise that could result in physiological effects depends on whether the short span or long span bridge replacement is chosen. Because the short span option involves the installation of more piles, more sturgeon are likely to be exposed to noise that could result in effects. Pile driving carried out for the short span bridge option is expected to result in the injury of 70 or fewer shortnose sturgeon and 70 or fewer Atlantic sturgeon (64 New York Bight DPS, four Chesapeake Bay DPS, and two Gulf of Maine DPS). Pile driving carried out for the long span bridge option is expected to result in the injury of 43 or fewer shortnose sturgeon and 43 or fewer Atlantic sturgeon (40 New York Bight DPS, two Chesapeake Bay DPS, and one Gulf of Maine DPS). Normal sturgeon behavior is expected to result in avoidance of areas loud enough to cause significant injury or mortality. However, due to the length of the project and the duration of pile driving, we expect that no more than one shortnose sturgeon and no more than one Atlantic sturgeon will suffer serious injury or mortality due to exposure to pile driving noise. The two Atlantic sturgeon that are likely to be seriously injured or killed during dredging and pile driving are likely to be New York Bight DPS; however it is possible that they could also originate from the Gulf of Maine or Chesapeake Bay DPS. As explained in the "Effects of the Action" section of the Opinion, with the exception of the one shortnose sturgeon and one Atlantic sturgeon, none of these sturgeon are expected to die, immediately or later, as a result of exposure to increased underwater noise levels resulting from pile driving. All injuries are anticipated to be minor and any injured individuals are expected to make a full recovery with no impact to future survival or fitness.

Additionally, any shortnose and Atlantic sturgeon present in the action area when impact pile driving is occurring may be exposed to levels of underwater noise which may alter their normal behaviors. These behaviors are expected to occur in areas where underwater noise is elevated above 150 dB re 1 μPa RMS. Behavioral changes could range from a startle response followed by resumption of normal behaviors to complete avoidance of the ensonified area over the duration that the elevated noise will be experienced. As explained above, effects of this temporary behavioral disturbance will be insignificant and discountable. As explained in the "Effects of the Action" section, effects of the bridge replacement project on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of piles by vibration, drilling to facilitate the installation of some piles, potential exposure to contaminants, a localized increase in vessel traffic, effects to prey items, and effects of dredge disposal at HARS. We have determined that all behavioral effects will be insignificant and discountable. We do not anticipate any take of shortnose sturgeon due to any of the other effects including vessel traffic and dredge disposal.

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

10.1 Shortnose sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard 1996), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

The Hudson River population of shortnose sturgeon is the largest in the United States. Historical estimates of the size of the population are not available as historic records of sturgeon in the river did not discriminate between Atlantic and shortnose sturgeon. Population estimates made by Dovel *et al.* (1992) based on studies from 1975-1980 indicated a population of 13,844 adults. Bain *et al.* (1998) studied shortnose sturgeon in the river from 1993-1997 and calculated an adult population size of 56,708 with a 95% confidence interval ranging from 50,862 to 64,072 adults. Bain determined that based on sampling effort and methodology his estimate is directly comparable to the population estimate made by Dovel *et al.* Bain concludes that the population of shortnose sturgeon in the Hudson River in the 1990s was 4 times larger than in the late 1970s. Bain states that as his estimate is directly comparable to the estimate made by Dovel, this increase is a "confident measure of the change in population size." Bain concludes that the Hudson River population is large, healthy and particular in habitat use and migratory behavior. Woodland and Secor (2007) conducted studies to determine the cause of the increase in population size. Woodland and Secor captured 554 shortnose sturgeon in the Hudson River and made age estimates of these fish. They then hindcast year class strengths and corrected for gear selectivity and cumulative mortality. The results of this study indicated that there was a period of high recruitment (31,000 – 52,000 yearlings) in the period 1986-1992 which was preceded and succeeded by 5 years of lower recruitment (6,000 – 17,500 yearlings/year). Woodland and Secor reports that there was a 10-fold recruitment variability (as measured by the number of yearlings produced) over the 20-year period from the late 1970s to late 1990s and that this pattern is expected in a species, such as shortnose sturgeon, with periodic life history characterized by delayed maturation, high fecundity and iteroparous spawning, as well as when there is variability in interannual hydrological conditions. Woodland and Secor examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults.

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

While no reliable estimate of the size of either the shortnose sturgeon population in the Northeastern US or of the species throughout its range exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed. Based on the number of adults in population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. The lack of information on the status of some populations, such as that in the Chesapeake Bay, add uncertainty to any determination on the status of this species as a whole. Based on the best available information, NMFS believes that the status of shortnose sturgeon throughout their range is stable (Bowers-Altman *et al.* 2012 Draft).

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Hudson River are affected by impingement at water intakes, habitat alteration, bycatch in commercial and recreational fisheries, water quality and in-water construction activities. It is difficult to quantify the number of shortnose sturgeon that may be killed in the Hudson River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions NMFS obtains some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Hudson River each year, with little if any mortality. NMFS has no reports of interactions or mortalities of shortnose sturgeon in the Hudson River resulting from dredging or other in-water construction activities. NMFS also has no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Hudson River since the 1970s when the CWA was implemented. NMFS also has anecdotal evidence that shortnose sturgeon are expanding their range in the Hudson River and fully utilizing the river from the Manhattan area upstream to the Troy Dam, which suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Roseton and Danskammer plants is regularly reported to NMFS. Since reporting requirements were implemented in 2000, less than the exempted number of takes (6 total for the two facilities) have occurred each year. Impingement also occurs at Indian Point; we have estimated an annual impingement rate of approximately eight sturgeon per year. Despite these ongoing threats, there is evidence that the Hudson River population of shortnose sturgeon experienced tremendous growth between the 1970s and 1990s and that the population is now stable at high numbers. Over the life of the action, shortnose sturgeon in the Hudson River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Hudson River population. Also, as discussed above, we do not expect shortnose sturgeon to experience any new effects associated with climate change during the 3-4 year duration of the bridge construction. While climate change related effects to distribution in the river may occur during the period that the new Tappan Zee Bridge is in existence, the presence of the new bridge will not exacerbate or contribute to these effects or impact the ability of shortnose sturgeon to adapt to changing conditions in the river. As such, NMFS expects that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

NMFS has estimated that the proposed bridge replacement project will result in minor injury to no more than 70 shortnose sturgeon and that two shortnose sturgeon are likely to be killed. Other than for the fish that are killed, physiological effects are expected to be limited to minor injuries that will not impair the fitness of any individuals or affect survival. Behavioral responses are expected to be temporally and spatially limited to the area and time when underwater noise levels are greater than 150dB RMS and as such will be limited to only several hours at a time, and always less than 12 hours per day for no more than 5 hours per day. The potential for behavioral responses is limited to the time when impact pile driving will take place and is therefore limited to a period of less than 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 some 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) it is extremely unlikely that there would be any delay to the spawning migration or abandonment of spawning migrations; (4) there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health, and, (5) any minor changes in behavior resulting from exposure to increased underwater noise associated with the pile driving will not preclude any shortnose sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected.

The number of shortnose sturgeon that are likely to die as a result of the proposed bridge replacement project (two), represents an extremely small percentage of the shortnose sturgeon population in the Hudson River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon rangewide, which is also stable. The best available population estimates indicate that there are approximately 56,708 (95% CI=50,862 to 64,072) adult shortnose sturgeon in the Hudson River and an unknown number of juveniles (Bain 2007). While the death of up to 2 shortnose sturgeon over the five year construction period will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population or its stable trend as this loss represents a very small percentage of the population (less than 0.004%).

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

The proposed action is not likely to reduce distribution because the action will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Hudson River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is less than 0.004% of the Hudson River population, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity.

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

Based on the information provided above, the death of up to two shortnose sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of this species (*i.e.*, 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 shortnose 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 shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (i.e., it will not increase the risk of extinction faced by this species) given that: (1) the population trend of shortnose sturgeon in the Hudson River is stable; (2) the death of up to two 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; (3) 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 not change the status or trends of the Hudson River population or the species as a whole; (4) 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, (5) 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 certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild. Here, NMFS considers the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in a small reduction in the number of shortnose sturgeon in the Hudson River and since it will not affect the overall distribution of shortnose sturgeon other than to cause minor temporary adjustments in movements in the action area. The proposed action will not utilize shortnose sturgeon for recreational, scientific or commercial purposes or affect the adequacy of existing regulatory mechanisms to protect this species. The proposed action is likely to result in the mortality of up to 2 shortnose sturgeon;

however, over the 5-year construction period, the loss of these individuals and what would have been their progeny is not expected to affect the persistence of the Hudson River population of shortnose sturgeon or the species as a whole. The loss of these individuals will not change the status or trend of the Hudson River population, which is stable at high numbers. As it will not affect the status or trend of this population, it will not affect the status or trend of the species as a whole. As the reduction in numbers and future reproduction is very small, this loss would not result in an appreciable reduction in the likelihood of improvement in the status of shortnose sturgeon throughout their range. The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction since the action will cause the mortality of only a small percentage of the shortnose sturgeon in the Hudson River and an even smaller percentage of the species as a whole and these mortalities are not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of no more than 2 shortnose sturgeon over the 5-year construction period is not likely to appreciably reduce the survival and recovery of this species.

10.2 Atlantic sturgeon

10.2.1 Determination of DPS Composition

As explained above, the proposed action is likely to result in the capture of three Atlantic sturgeon in the dredge, the injury of 70 or fewer Atlantic sturgeon due to exposure to underwater noise, and the mortality of two Atlantic sturgeon (one in the dredge and one due to noise exposure). We have considered the best available information to determine from which DPSs these individuals are likely to have originated. Using mixed stock analysis explained above, we have determined that Atlantic sturgeon in the action area likely originate from three DPSs at the following frequencies: NYB 92%; Gulf of Maine 6%; and, Chesapeake Bay 2%. Given these percentages, we expect that for the short span bridge option, of the 70 injured fish, 64 will originate from the NYB DPS, four from the GOM DPS and 2 from the CB DPS. Of the three fish likely to be captured in the dredge, two are likely to be from the NYB DPS and the other will be from the CB or GOM DPS. The two Atlantic sturgeon likely to be killed are most likely to be NYB DPS; however, it is possible that they could be GOM or CB fish.

For the long span bridge option, of the 43 injured fish, 40 will originate from the NYB DPS, 2 from the GOM DPS and 1 from the CB DPS. Of the three fish likely to be captured in the dredge, two are likely to be from the NYB DPS and the other will be from the CB or GOM DPS. The two Atlantic sturgeon likely to be killed are most likely to be NYB DPS; however, it is possible that they could be GOM or CB fish.

10.2.2 Gulf of Maine DPS

Individuals originating from the GOM DPS are likely to occur in the action area. The GOM DPS has been listed as threatened. While Atlantic sturgeon occur in several rivers in the GOM DPS, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available. We have estimated, based on fishery-dependent data, that there are approximately 166 mature adults in the GOM DPS, at least 498 subadults and additional numbers of juveniles (which remain in their natal river and would not be present in the action area). We expect that 6% of the 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. 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 have estimated that the proposed bridge replacement project will result in the capture or injury of 73 or fewer Atlantic sturgeon for the short span option and 46 for the long span option, of which 4 and 3 are likely to be from the GOM DPS, respectively. The following analysis applies to anticipated effects of capture and injury of up to 4 individuals, but given the nature of the effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 73 captured or injured fish being from the GOM DPS. We anticipate the mortality of two Atlantic sturgeon; these are both likely to originate from the NYB DPS; however, it is possible, although very unlikely, that one of these sturgeon could originate from the GOM DPS; therefore, we consider the effects to the GOM DPS from the loss of one subadult (>500mm TL <1,500 mm TL).

The death of one subadult Atlantic sturgeon from the GOM DPS over a 5-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.2% of the population, just considering the minimum estimated number of subadults). While the death of one subadult Atlantic sturgeon will reduce the number of GOM DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[13] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (less than 0.3%).

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 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. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

The proposed 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.

[13] The "adult equivalent" rate converts a number of subadults to adult equivalents (the number of subadults that would, through natural mortality, live to be adults; for Atlantic sturgeon, this is calculated as 0.48).

The proposed 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 Hudson River that may be used by GOM 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 ensonified area.

Based on the information provided above, the death of no more than one GOM DPS Atlantic sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the 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 over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of one subadult GOM DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of this 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 this subadult GOM DPS Atlantic sturgeon 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 individual foraging GOM DPS Atlantic sturgeon.

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

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of GOM DPS Atlantic sturgeon in any geographic area and thus, it will not affect the overall distribution of GOM DPS Atlantic sturgeon. The proposed action will not utilize GOM DPS Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the capture and injury of Atlantic sturgeon and the mortality of no more than one subadult GOM DPS Atlantic sturgeon; however, as explained above, the loss of this individual and what would have been their progeny is not expected to affect the persistence of the GOM DPS. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status of GOM DPS Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will cause the mortality of only a very small percentage of the species as a whole and this mortality is not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the GOM DPS can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of one subadult GOM DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

10.2.3 New York Bight DPS

Individuals originating from the NYB DPS are likely to occur in the action area. The NYB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Delaware and Hudson rivers. Kahnle *et al.* (2007) estimated that there is a mean annual total mature adult population of 863 Hudson River Atlantic sturgeon. Using fishery-dependent data we have estimated that there are 87 Delaware River origin adults; combined, we estimate a total adult population of 950 in the New York Bight DPS. We have also estimated that there are at least 2,850 subadults and additional numbers of juveniles. We expect that 92% of the Atlantic sturgeon in the action area will originate from the NYB DPS. These fish could be juveniles, subadults and, seasonally, adults. NYB DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the Hudson or Delaware River spawning populations or for the DPS as a whole.

We have estimated that the proposed bridge replacement project will result in the capture or injury of 73 or fewer Atlantic sturgeon for the short span option and 46 for the long span option, of which 64 and 40 are likely to be from the NYB DPS, respectively. The following analysis applies to anticipated effects of capture and injury of up to 64 individuals, but given the nature of the effects (i.e., minor injuries that will have no impact on fitness), it applies equally well to the worst case, the unlikely scenario of all 73captured or injured fish being from the NYB DPS. The majority of individuals are likely to be Hudson River origin, but some may be Delaware River origin. We anticipate the mortality of two Atlantic sturgeon; these are most likely to originate from the NYB DPS. One mortality is expected during dredging and one due to exposure to underwater noise during pile driving. We expect that these mortalities will be juveniles (<500 mm TL) or subadults (<1,500 mm TL).

The mortality of two juvenile or subadult Atlantic sturgeon from the NYB DPS over a 5-year period represents a very small percentage of the subadult and juvenile population (*i.e.*, approximately 0.07% of the population, just considering the minimum estimated number of subadults). While the death of two juvenile or subadult Atlantic sturgeon will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the juvenile and subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting these two fish to adult equivalents[14]

[14] The "adult equivalent" rate converts a number of subadults to adult equivalents (the number of subadults that would, through natural mortality, live to be adults; for Atlantic sturgeon, this is calculated as 0.48).

(assuming they were both subadults; using a conversion rate of 0.48 considering the adult equivalent), and assuming no growth in the adult population, these two mortalities represent an extremely small percentage of the adult population (approximately 0.1%).

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

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

The proposed action is not likely to reduce distribution because the action will not impede Atlantic 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 Atlantic sturgeon.

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

Based on the information provided above, the death of up to two shortnose sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of two juvenile or subadult NYB DPS Atlantic sturgeon over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of two juvenile or subadult NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these juvenile or subadult NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these juvenile or subadult 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; (5) 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, (6) 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 certain instances an action that does not appreciably reduce the likelihood of a species survival (persistence) may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that NYB DPS Atlantic sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of NYB DPS Atlantic sturgeon in any geographic area and thus, it will not affect the overall distribution of NYB DPS Atlantic sturgeon. The proposed action will not utilize NYB DPS Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the capture and injury of Atlantic sturgeon and the mortality of two juvenile or subadult NYB DPS Atlantic sturgeon; however, as explained above, the loss of these individuals and what would have been their progeny is not expected to affect the persistence of the NYB DPS. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status of NYB DPS Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will cause the mortality of only a very small percentage of the species as a whole and these mortalities are not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that NYB DPS can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of one subadult NYB DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

10.2.4 Chesapeake Bay DPS

Individuals originating from the CB DPS are likely to occur in the action area. The CB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the CB DPS, recent spawning has only been documented in the James River. Using fishery-dependent data, we have estimated that there are 329 adults in the James River population, 987 subadults and additional juveniles (which remain in the James River). Because the James River is the only river in this DPS known to support spawning, this is also an estimate of the total number of adults and subadults in the Chesapeake Bay DPS. We expect that 2% of the 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. 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.

We have estimated that the proposed bridge replacement project will result in the capture or injury of 73 or fewer Atlantic sturgeon for the short span option and 46 for the long span option, of which 3 and 2 are likely to be from the CB DPS, respectively. The following analysis applies to anticipated effects of capture and injury of up to 3 individuals, 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 73 captured or injured fish being from the CB DPS. We anticipate the mortality of two Atlantic sturgeon; these are both likely to originate from the NYB DPS; however, it is possible, although very unlikely, that one of these sturgeon could originate from the CB DPS; therefore, we consider the effects to the CB DPS from the loss of one subadult (>500mm TL <1,500 mm TL).

The death of one subadult Atlantic sturgeon from the CB DPS over a 5-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.1% of the population, just considering the minimum estimated number of subadults). While the death of one subadult Atlantic sturgeon will reduce the number of CB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[15] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (less than 0.2%).

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 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. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

The proposed action will also not affect the spawning grounds within the rivers where CB 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 CB DPS fish.

The proposed 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 Hudson

[15] The "adult equivalent" rate converts a number of subadults to adult equivalents (the number of subadults that would, through natural mortality, live to be adults; for Atlantic sturgeon, this is calculated as 0.48).

River 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 ensonified area.

Based on the information provided above, the death of no more than one CB DPS Atlantic sturgeon over a 5-year period resulting from the proposed construction of a bridge to replace the existing Tappan Zee Bridge, will not appreciably reduce the likelihood of survival of the 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 over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of one subadult CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of this subadult CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of this subadult CB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of CB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging CB DPS Atlantic sturgeon.

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

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of CB DPS Atlantic sturgeon in any geographic area and thus, it will not affect the overall distribution of CB DPS Atlantic sturgeon. The proposed action will not utilize CB DPS Atlantic sturgeon for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the capture and injury of Atlantic sturgeon and the mortality of no more than one subadult CB DPS Atlantic sturgeon; however, as explained above, the loss of this individual and what would have been their progeny is not expected to affect the persistence of the CB DPS. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status of CB DPS Atlantic sturgeon. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will cause the mortality of only a very small percentage of the species as a whole and this mortality is not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the CB DPS can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, resulting in the mortality of one subadult CB DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

11.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed replacement of the Tappan Zee Bridge as described in section 3.0 of this Opinion, may adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of Atlantic sturgeon. We have also determined that the proposed action, specifically the disposal of dredged material at the HARS, may affect but is not likely to adversely affect any species of whale or sea turtle. No critical habitat is designated in the action area; therefore, none will be affected by the proposed action.

12.0 INCIDENTAL TAKE STATEMENT

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

12.1 Amount or Extent of Take

Dredging to be carried out during the bridge replacement project is expected to result in the capture of three shortnose sturgeon and three Atlantic sturgeon (two New York Bight DPS and one Gulf or Maine or Chesapeake Bay DPS), with the injury or mortality of one of these shortnose sturgeon and one of these Atlantic sturgeon (originating from the New York Bight, Gulf of Maine or Chesapeake Bay DPS). This amount of take applies for either the short span or long span bridge replacement.

The amount of take resulting from pile driving depends on whether the short span or long span bridge replacement is chosen. Because the short span option involves the installation of more piles, more sturgeon are likely to be exposed to noise that could result in effects. Pile driving carried out for the short span bridge option is expected to result in the injury of 70 or fewer shortnose sturgeon and 70 or fewer Atlantic sturgeon (64 New York Bight DPS, four Chesapeake Bay DPS and two Gulf of Maine DPS), with one shortnose sturgeon and one Atlantic sturgeon experiencing serious injury or mortality. Pile driving carried out for the long span bridge option is expected to result in the injury of 43 or fewer shortnose sturgeon and 43 or fewer Atlantic sturgeon (40 New York Bight DPS, two Chesapeake Bay DPS and one Gulf of Maine DPS), with one shortnose sturgeon and one Atlantic sturgeon experiencing serious injury or mortality. The two Atlantic sturgeon that are likely to be seriously injured or killed during dredging and pile driving are likely to be New York Bight DPS; however it is possible that they could also originate from the Gulf of Maine or Chesapeake Bay DPS. As explained in the "Effects of the Action" section of the Opinion, with the exception of the one shortnose sturgeon and one Atlantic sturgeon, none of these sturgeon are expected to die, immediately or later, as a result of exposure to increased underwater noise levels resulting from pile driving. All other take is likely to be in the form of injury. All injuries are anticipated to be minor and any injured individuals are expected to make a full recovery with no impact to future survival or fitness.

As explained in the "Effects of the Action" section, effects of the bridge replacement project on shortnose and Atlantic sturgeon also include exposure to noise resulting from the installation of piles by vibration, drilling to facilitate the installation of some piles, potential exposure to contaminants, a localized increase in vessel traffic, effects to prey items, and effects of dredge disposal at HARS. We have determined that all behavioral effects will be insignificant and discountable. We do not anticipate any take of shortnose sturgeon due to any of the other effects including vessel traffic and dredge disposal.

This ITS exempts the following take:

Short Span Bridge Option		
	Shortnose Sturgeon	**Atlantic Sturgeon**
Type of Take		
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	70 (juvenile or adult)	70 total 64 NYB DPS (juvenile, subadult or adult) 4 GOM DPS (subadult or adult) 2 CB DPS (subadult or adult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

Long Span Bridge Option		
	Shortnose Sturgeon	**Atlantic Sturgeon**
Type of Take		
Capture	3 (juvenile or adult)	3 total: 2 juvenile or subadult NYB DPS, one subadult GOM or CB DPS
Injury	43 (juvenile or adult)	43 total 40 NYB DPS (juvenile, subadult or adult) 2 GOM DPS (subadult or adult) 1 CB DPS (subadult)
Mortality	2 (juvenile or adult)	2 total: 2 juvenile or subadult NYB DPS ***or*** 1 juvenile or subadult NYB DPS and 1 subadult GOM DPS or 1 subadult CB DPS

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

Observers will be present to monitor all dredging activity; therefore, we expect that all take associated with dredging will be observed. While we have been able to estimate the likely number of shortnose and Atlantic sturgeon to be taken as a result of the bridge replacement project, it may be impossible to observe all sturgeon affected by the pile installation. This is because both shortnose and Atlantic sturgeon are aquatic species that spend the majority of their time near the bottom, making it very difficult to monitor movements of individual sturgeon in the action area to document changes in behavior or to capture all affected individuals to document injuries. Because of this, the likelihood of discovering take attributable to this proposed action is very limited. There is no practical way to monitor the entire ensonified area during test pile installations to document the number of sturgeon exposed to underwater noise. FHWA will carry out a monitoring plan during pile installation including monitoring the project area for the presence of injured or dead fish. We expect that any sturgeon that are seriously injured or killed would be detected because we expect that these fish would be present at the river surface and therefore, be observable. The difficulty is monitoring fish that remain underwater and experience minor injuries.

We considered several methods to monitor the validity of our estimates that there will be 70 or fewer or 43 or fewer (depending on the bridge design), shortnose and 70 or fewer, or 43 or fewer Atlantic sturgeon total from the New York Bight, Gulf of Maine and Chesapeake Bay DPSs exposed to underwater noise that would result in injury. We considered requiring monitoring for sturgeon with gillnets or trawls within the ensonified area; however, because we expect the pile driving noise to cause sturgeon to leave the area, this method would not likely provide us with relevant information regarding the number of sturgeon affected. We also considered requiring surveys outside of the ensonfied area; however, this would possibly intercept sturgeon that were displaced from the ensonified area as well as fish that were present in the area being sampled, but not because of displacement. Thus, using this approach, it would be difficult to determine anything meaningful about the number of sturgeon affected by the bridge replacement project. In addition, gillnets may be very effective at catching sturgeon; however, we chose a method of monitoring take that would not exacerbate adverse effects. Also, because we expect a wide variety of size classes of sturgeon to be present in the area near the bridge and different mesh sizes would be needed to catch different size fish, it would be difficult to establish a sampling design that would effectively capture fish of all size classes at all times. Sturgeon captured in trawls generally have a lower mortality rate than those captured in gillnets, however, there may be added stress upon capture. The fish, particularly larger fish, may also be able to avoid a trawl. We also considered whether monitoring of tagged sturgeon would allow us to monitor take. However, because we do not know what percentage of sturgeon in the action area are likely to be tagged, it is not possible to determine the total number of sturgeon affected by the action based on the number of tagged sturgeon detected in the area. Further, if no tagged sturgeon were detected, we could not use that information to determine that no sturgeon were affected because it may just mean that there were no tagged sturgeon in the area.

Because we have dismissed all of these monitoring methods as neither reasonable nor appropriate, we will use a means other than counting individuals to assess the level of take. In situations where we cannot observe the actual individuals affected, the proxy must be rationally connected to the taking and provide an obvious threshold of exempted take which, if exceeded, provides a basis for reinitiating consultation. For this proposed action, the spatial and temporal extent of the area where underwater noise levels will be greater than 206 dB re 1uPa peak provides a proxy for estimating the actual amount of incidental take. We expect that this proxy will be the primary method of determining whether incidental take has been exceeded, given the potential that stunned or injured fish will not be observed. However, in order to increase the chances of detecting when incidental take has been exceeded, we have identified other methods as well. Because all of the calculations that were used to generate the take estimates are based on worst-case scenarios, including: 100% installation of all piles with an impact hammer (when it is likely that all piles will be at least partially installed with a vibratory hammer); and, 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 70 shortnose sturgeon are observed stunned or injured.

ii) More than one dead shortnose sturgeon or more than one dead Atlantic sturgeon (belonging to the NYB, CB or GOM DPS) are observed during pile driving with injuries that are attributable to project operations.

iii) More than 52 New York Bight DPS, three Chesapeake Bay DPS, and two Gulf of Maine DPS Atlantic sturgeon are observed stunned or injured.

iv) More than three shortnose sturgeon and more than three Atlantic sturgeon (two NYB DPS and one CB or GOM DPS) are observed captured during mechanical dredging.

v) More than one shortnose sturgeon or more than one Atlantic sturgeon (belonging to the NYB, CB or GOM DPS) are injured or killed during mechanical dredging.

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

(a) The geographic extent of the area where noise is greater than 206 dB re 1 μPa peak is greater than the area considered in the "Effects of the Action" section of this Opinion, which is related to the area used to calculate the number of takes anticipated, and is listed in Tables 12 and 13.

(b) We will consider whether incidental take was exceeded if the number of hours that impact pile driving occurs exceeds the amount of time listed in Tables 12 and 13, which is related to the amount of time used to calculate the number of takes anticipated.

Some of the methods above (iv, v and vi) would depend on the ability to obtain a fin clip for genetic testing and assignment of the fish to one of the DPSs. It is expected that genetic test results could be obtained in time to reinitiate consultation prior to completion of the bridge replacement project as we anticipate receiving genetic information within approximately one month of submitting samples for processing.

12.2 Reasonable and Prudent Measures

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

We believe the following reasonable and prudent measures are necessary or appropriate for FHWA to minimize and monitor impacts of incidental take of listed shortnose and Atlantic sturgeon. Please note that these reasonable and prudent measures and terms and conditions are in addition to the Environmental Performance Commitments that FHWA has committed to employ during the project (see Section 3.3). Because the Environmental Performance Commitments will become mandatory requirements of any contracts issued, we do not repeat them here as they are considered to be part of the proposed action.

RPMs Specific to Dredging Activities:

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

consultation.

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

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

RPMs Specific to Pile Driving Activities:

4. FHWA must implement a program to monitor underwater noise resulting from the installation of piles during pile installation operations.

5. FHWA must implement a program to monitor impacts to sturgeon resulting from pile installation throughout the duration of pile driving operations.

RPMs for all aspects of the project:

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

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

8. 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.

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

10. All sturgeon captures, injuries or mortalities associated with the bridge replacement project and any sturgeon sightings in the action area must be reported to NMFS within 24 hours.

12.3 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 taking that is in compliance with the terms and conditions specified in this Incidental Take Statement shall not be considered a prohibited taking of the species concerned (ESA Section 7(o)(2)). In carrying out all of these terms and conditions, FHWA as lead Federal agency in this consultation, is responsible for coordinating with the other Federal agencies that are party to the consultation, as well as with project sponsors and contractors.

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

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

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

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

5. To implement RPM #3, FHWA, in coordination with the ACOE, EPA, project sponsors and contractors as appropriate, any sturgeon observed in the dredge bucket or dredge scow during mechanical dredging operations must be removed with a net and, if alive, returned to the river away from the project site.

6. To implement RPM #4, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with a representative number of each size of piles. The monitoring program must be sufficient to establish the peak sound level and distance from the pile to this sound level, the cumulative sound exposure level and the distance at which sound will be greater than 206 dB re 1 μPa Peak, 187 dB re 1 μPa^2-s cSEL and 150 dB re 1 μPa RMS. The monitoring program must also document the duration (i.e., minutes/hours) of time it takes to install each pile and the duration of time the area is ensonified during each 24 hour period.

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

8. To implement RPM#4, FHWA must ensure an acoustic monitoring program is implemented that is able to document the underwater noise associated with installing piles with a vibratory

method. The monitoring program must be sufficient to establish the peak sound level and the RMS level.

9. To implement RPM#4, FHWA must report results from the sound monitoring to NMFS as soon as practicable, but no less frequently than every 30 days. If there is any indication that peak noise levels have exceeded 206 dB re 1 μPa peak or 187 dB re 1 μPa^2-s cSEL for longer than anticipated or over a greater geographic area than anticipated, NMFS must be contacted immediately. Monthly reports must be provided to NMFS in a format that allows comparison to the information presented in tables 12 and 13 in the Opinion; therefore they must include the noise information and the duration of pile driving activities.

10. To implement RPM#5, FHWA must ensure acoustic telemetry equipment is utilized to monitor for the presence, residence time and movement of tagged Atlantic and shortnose sturgeon in the project area. FHWA must design a monitoring plan that would ensure the detection of any acoustically tagged shortnose or Atlantic sturgeon in the action area. This monitoring plan must be approved by NMFS prior to the installation of the first pile. FHWA must ensure all occurrences of tagged sturgeon in the project area are recorded. Information collected from any stationary receivers must be downloaded at least every thirty days. Preliminary reports containing information on the number of tagged sturgeon detected must be provided to NMFS on a regular basis, but no less frequently than every 60 days. If reports cannot be provided on that frequency, FHWA must provide an explanation to NMFS within the 60 day period and provide the report as soon as possible. On a quarterly basis, FHWA must provide NMFS a report that summarizes all available information from the monitoring equipment on sturgeon detections and movements for the previous 120 day period. This term and condition does not require FHWA to tag any sturgeon with telemetry tags.

11. To implement RPM#5, FHWA must ensure the project area is monitored for the presence of any floating dead or injured sturgeon. FHWA must design a monitoring plan that would ensure the detection of any floating stunned, injured or dead sturgeon. We anticipate that this would be accomplished by using at least one small boat to run transects through the project area during and after the installation of piles installed with impact hammers and at least one monitor on the barge next to the pile being driven with radio communication to the boat. The location of the transects must take tidal currents into consideration. This plan must be approved by NMFS prior to the installation of any piles by impact hammer. Preliminary reports containing information on the number of fish observed stunned or injured (including non-sturgeon species) must be reported to NMFS on a regular basis, but no less frequently than every 60 days. If reports can not be provided on that frequency, FHWA must provide an explanation to NMFS within the 60 day period and provide the report as soon as possible. On a quarterly basis, FHWA must provide NMFS a report that summarizes all available information from the monitoring program on all fish observed in the area during the previous 120 day period.

12. To implement RPM#6, FHWA must ensure any observed live sturgeon are collected with a net and are visually inspected for injuries. Unless the size of fish precludes holding, collected fish must be held on board a vessel with a flow through live well.

13. To implement RPM #7, FHWA must ensure that fin clips are taken (according to the procedure outlined in Appendix C) of any sturgeon captured during the project and that the fin clips are sent to NMFS for genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies.

14. To implement RPM #8, FHWA must ensure all collected sturgeon must be inspected for a PIT tag with an appropriate PIT tag reader and tagged if no PIT tag is detected according to the protocol provided as Appendix D. Injured fish must be visually assessed, measured, photographed, released away from the site and reported to NMFS.
15. To implement RPM#9, FHWA must ensure that any observed dead sturgeon are collected with a net, reported to NMFS, preserved as appropriate to allow for necropsy, and that NMFS is contacted immediately to discuss necropsy and other procedures. NMFS may request that the specimen be transferred to NMFS or to an appropriately permitted researcher approved by NMFS so that a necropsy may be conducted. The form included as Appendix E must be completed and submitted to NMFS.
16. To implement RPM #10, 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 immediately and that an incident report (Appendix F) is completed by the observer and sent to the NMFS Section 7 Coordinator via FAX (978-281-9394) or e-mail (incidental.take@noaa.gov) within 24 hours of the take. FHWA must also ensure that every sturgeon is photographed. Information in Appendix G will assist in identification of shortnose and Atlantic sturgeon.

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

RPM #1 and Term and Condition #1 and #2 are necessary and appropriate because they will serve to ensure that NMFS is aware of the dates and locations of all dredging. This will allow NMFS to monitor the duration and seasonality of dredging activities as well as give NMFS an opportunity to provide FHWA with any updated contact information for NMFS staff. This is only a minor change because it is not expected to result in any delay to the project and will merely involve an occasional telephone call or e-mail between FHWA and NMFS staff.

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

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

RPM #4 and #5 Term and Condition #6-11 are necessary and appropriate because they are specifically designed to monitor underwater noise associated with the pile driving. Because our calculation of take is tied to the geographic area where increased underwater noise will be experienced, it is critical that acoustic monitoring take place to allow FHWA to fulfill the requirement to monitor the actual level of incidental take associated with the pile driving and to allow NMFS and FHWA to determine if the level of incidental take is ever exceeded. Monitoring with acoustic receivers will detect the presence and movements of tagged sturgeon in the action area and should also provide us with information on residence times and movements within the action area. We expect this data will provide important information on the behavioral responses of tagged sturgeon to the pile driving activities. 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#6-8 and Term and Condition #12-14 are necessary and appropriate to maximize the potential for detection of any affected sturgeon. These measures will ensure that any sturgeon that are observed injured are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality by being further subject to increased underwater noise. The taking of fin clips allows NMFS to run genetic analysis to determine the DPS of origin for Atlantic sturgeon. This allows us to determine if the actual level of take has been exceeded. Sampling of fin tissue is used for genetic sampling. This procedure does not harm sturgeon and is common practice in fisheries science. Tissue sampling does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact. Checking and tagging fish with PIT tags allows FHWA to determine the identity of detected fish and determine if the same fish is detected more than once. PIT tagging is not known to have any adverse impact to fish. NMFS has received no reports of injury or mortality to any sturgeon sampled or tagged in this way. This represents only a minor change as following these procedures will have an insignificant impact on the cost of the project and will not result in any delays.

RPM #9 and Term and Condition #15 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 #10 and Term and Condition #16 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.

13.0 CONSERVATION RECOMMENDATIONS

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

1. The FHWA should use its authorities to ensure tissue analysis of any dead sturgeon removed from the Hudson River during the course of the bridge construction project to determine contaminant loads.
2. The FHWA should use its authorities to support studies on shortnose and Atlantic sturgeon distribution of individuals in the Tappan Zee reach of the Hudson River. Such studies could involve site specific surveying or monitoring, targeted at the collection of these species, in the months prior to any bridge replacement or other project, aimed at further documenting seasonal presence in the action area and further documenting the extent that individuals use different parts of the action area (i.e., the deepwater channel vs. shallower areas near the shoreline).
3. The FHWA should use its authorities to support studies on the distribution of shortnose and Atlantic sturgeon throughout different habitat types within the Hudson River. Such studies could include tagging and tracking studies and use of gross and fine scale acoustic telemetry equipment to monitor movements of individual fish throughout the river. This information would add to our knowledge of habitat selection and seasonal distribution throughout the river.
4. The FHWA should use its authorities to support studies necessary to update population estimates for the Hudson River population of shortnose sturgeon and the Hudson River population of Atlantic sturgeon.
5. The FHWA should use its authorities to conduct post-construction monitoring of the benthic environment to document recovery rates of benthic invertebrates in areas where temporary platforms were constructed, the existing bridge was removed and where dredging and/or armoring occurred.

14.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the Tappan Zee Bridge replacement project. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately.

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APPENDIX A

MONITORING SPECIFICATIONS FOR MECHANICAL DREDGES

I. EQUIPMENT SPECIFICATIONS

A. Floodlights

Should dredging occur at night or in poor lighting conditions, floodlights must be installed to allow the NMFS-approved observer to safely observe and monitor dredge bucket and scow.

B. Intervals between dredging

Sufficient time must be allotted between each dredging cycle for the NMFS-approved observer to inspect the dredge bucket and scow for shortnose sturgeon and/or sturgeon parts and document the findings.

II. OBSERVER PROTOCOL

A. Basic Requirement

A NMFS-approved observer with demonstrated ability to identify shortnose sturgeon must be placed aboard the dredge(s) being used; starting immediately upon project commencement to monitor for the presence of listed species and/or parts being taken or present in the vicinity of dredge operations.

B. Duty Cycle

A NMFS-approved observers must be onboard during dredging until the project is completed. While onboard, observers shall provide the required inspection coverage to provide 100% coverage of all dredge-cycles.

C. Inspection of Dredge Spoils

During the required inspection coverage, the NMFS-approved observer shall observe the bucket as it comes out of the water and as the load is deposited into the scow during each dredge cycle for evidence of shortnose sturgeon. If any whole sturgeon (alive or dead) or sturgeon parts are taken incidental to the project(s), NMFS ((978) 281-9328) must be contacted by phone **within 24 hours** of the take. An incident report for sturgeon take shall also be completed by the observer and sent to NMFS via FAX (978) 281-9394 or e-mail (indicidental.take@noaa.gov) within 24 hours of the take. Incident reports shall be completed for every take regardless of the state of decomposition. Every incidental take (alive or dead, decomposed or fresh) must be photographed. A final report including all completed load sheets, photographs, and relevant incident reports are to be submitted to the attention of the Section 7 Coordinator, NMFS Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930.

D. Inspection of Disposal

The NMFS-approved observer shall observe all disposal operations to inspect for any whole sturgeon or sturgeon parts that may have been missed when the load was deposited into the scow. If any whole sturgeon (alive or dead) or sturgeon parts are observed during disposal operation, the procedure for notification and documentation outlined above should be completed.

E. Disposition of Parts

As required above, NMFS must be contacted as soon as possible following a take. Any dead sturgeon should be held in cold storage until disposition can be discussed with NMFS. Under no circumstances should dead sturgeon be disposed of without confirmation of disposition details with NMFS.

APPENDIX B.

OBSERVER REQUIREMENTS

Submission of resumes of endangered species observer candidates to NMFS for final approval ensures that the observers placed onboard the dredges are qualified to document takes of endangered and threatened species, to confirm that incidental take levels are not exceeded, and to provide expert advice on ways to avoid impacting endangered and threatened species. NMFS does not offer certificates of approval for observers, but approves observers on a case-by-case basis.

A. Qualifications

Observers must be able to:

1) differentiate between shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus oxyrinchus*) sturgeon and their parts;
2) handle live sturgeon;
3) correctly measure the total length and width of live and whole dead sturgeon species;

B. Training

Ideally, the applicant will have educational background in biology, general experience aboard dredges, and hands-on field experience with the species of concern. For observer candidates who do not have sufficient experience or educational background to gain immediate approval as endangered species observers, we note below the observer training necessary to be considered admissible by NMFS. We can assist the FHWA by identifying groups or individuals capable of providing acceptable observer training. Therefore, at a minimum, observer training must include:

1) instruction on how to identify sturgeon and their parts;

2) instruction on appropriate screening on hopper dredges for the monitoring of sturgeon(whole or parts);

3) demonstration of the proper handling of live sturgeon incidentally captured during project operations;

4) instruction on standardized measurement methods for sturgeon lengths and widths; and
5) instruction on dredging operations and procedures, including safety precautions onboard.

APPENDIX C

Procedure for obtaining fin clips from sturgeon for genetic analysis

Obtaining Sample

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

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

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

Storage of Sample

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

Sending of Sample

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

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

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

APPENDIX D.

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.

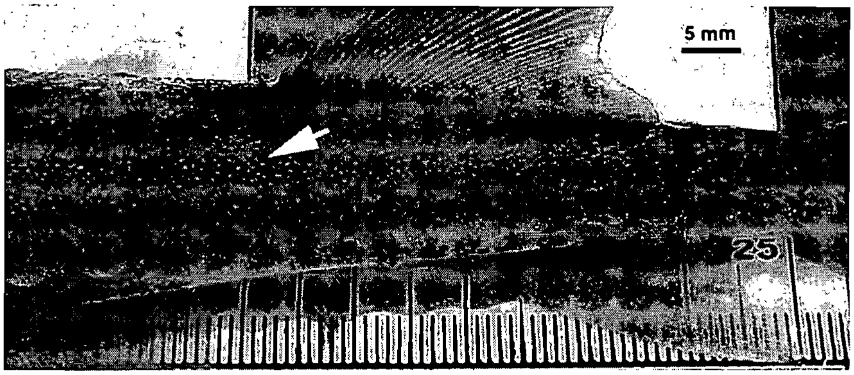
It is recommended that the needles and PIT tags be disinfected in isopropyl alcohol or equivalent rapid acting disinfectant. After any alcohol sterilization, we recommend that the instruments be air dried or rinsed in a sterile saline solution, as alcohol can irritate and dehydrate tissue (Joel Van Eenennam, 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 15). 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.



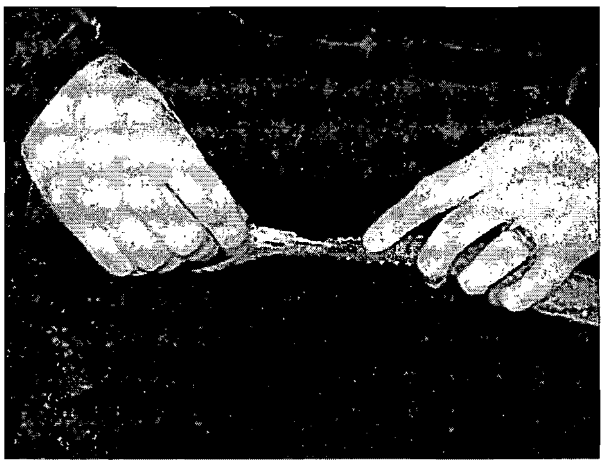


Figure 15. (from Damon-Randall *et al.* 2010). Illustration of PIT tag location (indicated by white arrow; top), and photo of a juvenile Atlantic sturgeon being injected with a PIT tag (bottom). *Photos courtesy of James Henne, US FWS.*

Appendix E

STURGEON SALVAGE FORM

For use in documenting dead sturgeon in the wild under ESA permit no. 1614 (version 05-16-2012)

INVESTIGATORS'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:

____

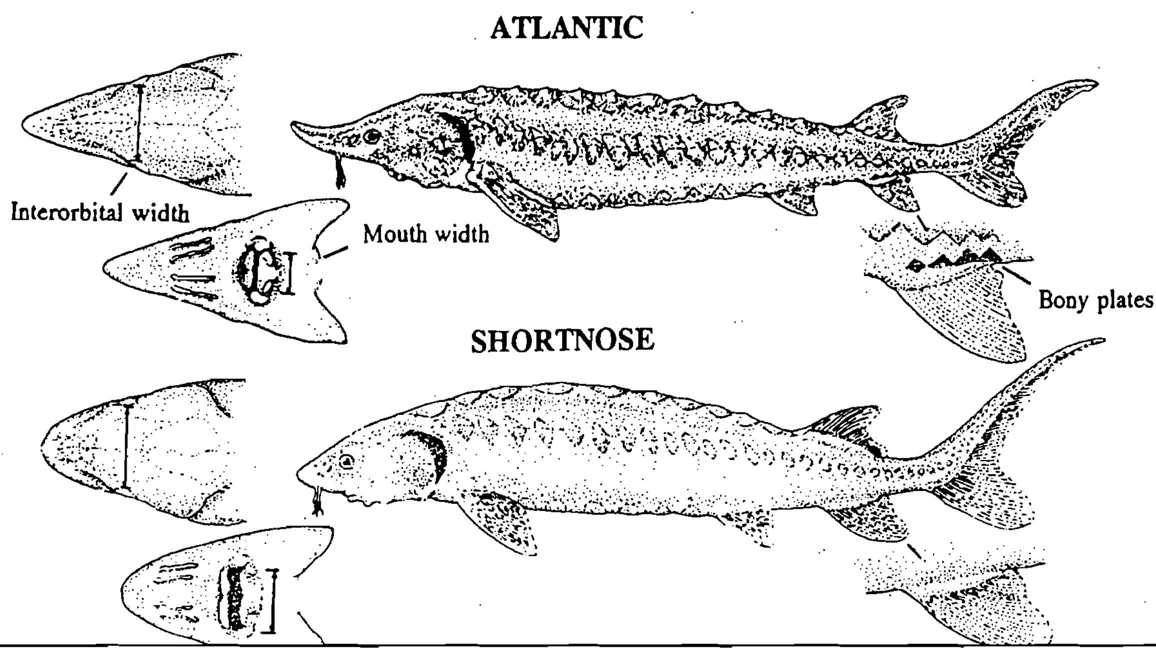
____

____

Distinguishing Characteristics of Atlantic and Shortnose Sturgeon (version 07-20-2009)

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



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

____

____

____

____

____

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

Submit completed forms (within 30 days of date of investigation) to: Northeast Region Contacts – Shortnose Sturgeon Recovery Coordinator (Jessica Pruden, Jessica.Pruden@noaa.gov, 978-282-8482) or Atlantic Sturgeon Recovery Coordinator (Lynn Lankshear, Lynn.Lankshear@noaa.gov, 978-282-8473); **Southeast Region Contacts**- Shortnose Sturgeon Recovery Coordinator (Stephania Bolden, Stephania.Bolden@noaa.gov, 727-824-5312) or Atlantic Sturgeon Recovery Coordinator (Kelly Shotts, Kelly.Shotts@noaa.gov, 727-551-5603).

APPENDIX F

Incident Report: Sturgeon Take – Tappan Zee Replacement Project

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

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

Species Identification:________________________________

Describe project activities (i.e., dredging, pile driving, etc.) ongoing within 24 hours of observation:____
____

Date animal observed:____________ Time animal observed: __________________
Date animal collected:____________ Time animal collected:__________________

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

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

Sturgeon Information:
Species ___________________________

Fork length (or total length) __________________ Weight __________________

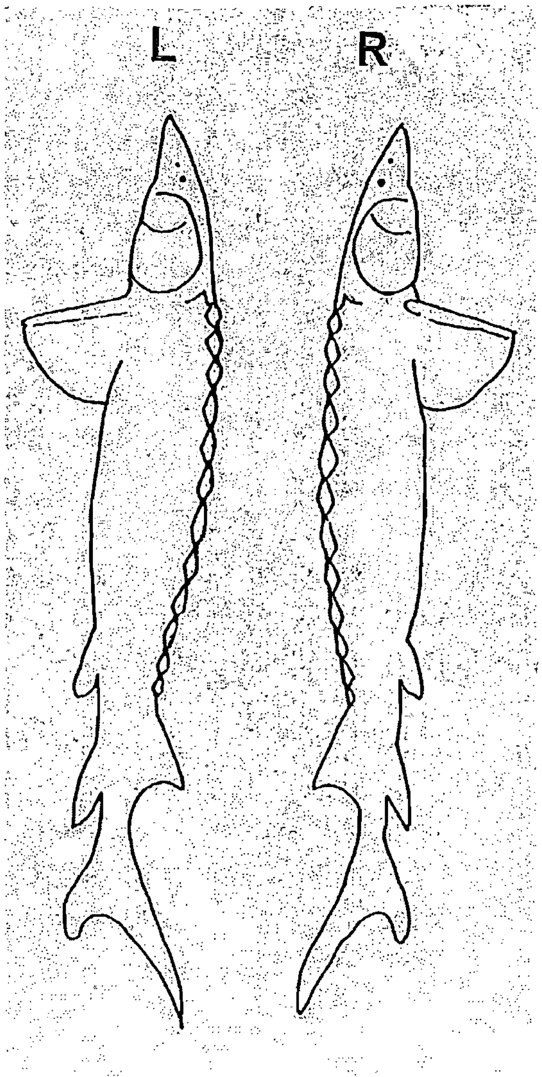
Condition of specimen/description of animal
____
____
____
____

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

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

Appendix F, continued

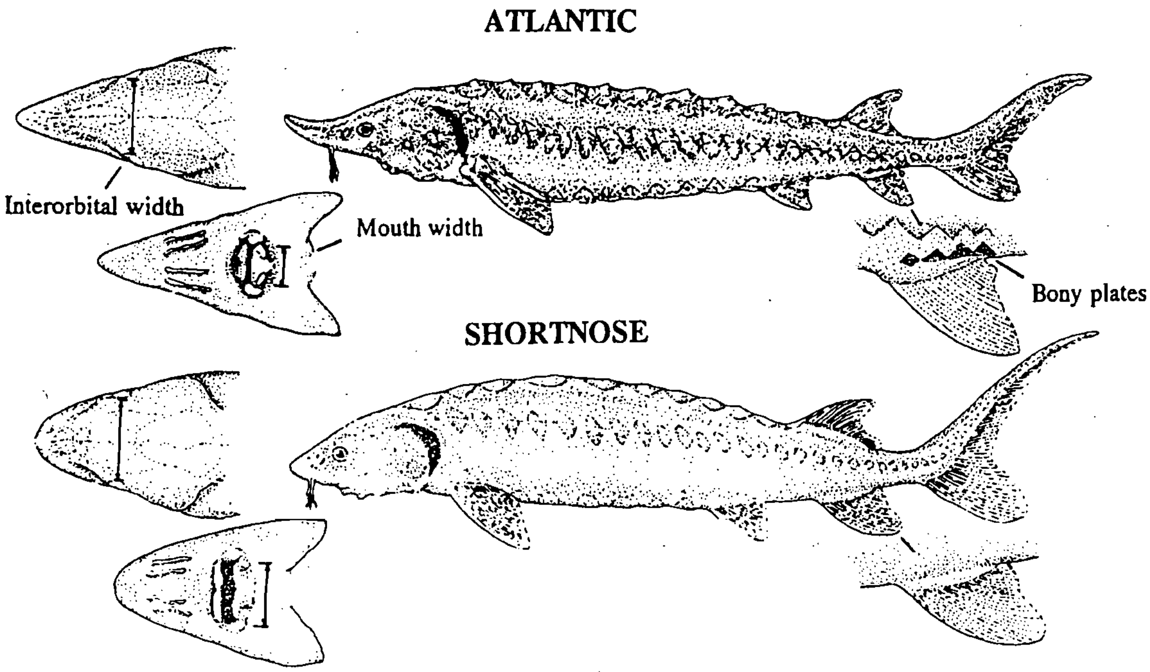
Draw wounds, abnormalities, tag locations on diagram and briefly describe below



Description of fish condition:

APPENDIX G

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



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From Vecsei and Peterson, 2004