

**NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION**

Agency: Army Corps of Engineers (USACE), Philadelphia District

Activity Considered: Deepening of the Delaware River Federal Navigation Channel
(Reinitiation)
NER-2015-12624

Conducted by: National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office

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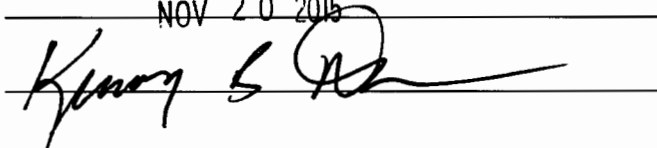
Approved by: 

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1.0 INTRODUCTION

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of the U.S. Army Corps of Engineers (USACE) ongoing deepening of the Delaware River Federal navigation channel from Philadelphia to the Sea. This Opinion is based on information provided in the Biological Assessment (BA) dated January 2009; a supplement to the BA dated February 9, 2009; a further supplement dated March 2011; an Environmental Assessment (EA) for the Deepening project dated April 2009; a supplement to the EA dated September 2011; a plan for the proposed relocation trawl study dated November 2013; a November 27, 2013 submittal to us regarding the Oakwood Beach project, including the November 2013 draft EA; a report on the feasibility of using underwater sound to behaviorally exclude sturgeon from a blasting area dated July 30, 2015, a final sturgeon monitoring and protection plan dated August 25, 2015, our October 25, 1996 Opinion on dredging in the Philadelphia District of the USACE; a May 25, 1999 supplement to the 1996 Opinion; the February 2, 2001 Opinion on the Delaware River Main Channel Blasting Project; our July 2009, July 2012, and January 2014 Opinions on the deepening project; and, scientific papers and other sources of information as cited in this Opinion. A complete administrative record of this consultation will be kept at the NMFS Greater Atlantic Regional Fisheries Office.

2.0 PROJECT HISTORY

2.1 Delaware River Channel

The existing Delaware River Philadelphia to the Sea Federal navigation project was authorized by Congress in 1910 and modified in 1930, '35, '38, '45, '54 and '58. This 155.3 km (96.5 mile) long channel is authorized for depths of 37 to 40 feet. The existing project provides for a channel from deep water in Delaware Bay to a point in the Bay, near Ship John Light, 40 feet deep¹ and 1,000 feet wide; thence to the Philadelphia Naval Base, 40 feet deep and 800 feet wide, with a 1,200-foot width at Bulkhead Bar and a 1,000-foot width at other channel bends; thence to Allegheny Avenue Philadelphia, PA; 40 feet deep and 500 feet wide through Horseshoe Bend and 40 feet deep and 400 feet wide through Philadelphia Harbor along the west side of the channel. The east side of the channel in Philadelphia Harbor has a depth of 37 feet and a width of 600 feet. The 40-foot channel from the former Naval Base to the sea was completed in 1942. The channel from the former Naval Base to Allegheny Avenue was completed in 1962. There are 19 anchorages on the Delaware River. The Mantua Creek, Marcus Hook, Deepwater Point, Reedy Point, Gloucester and Port Richmond anchorages are authorized under the Philadelphia to the Sea project. The remaining 13 are natural, deep-water anchorages. The authorized anchorage dimensions are as follows: Mantua Creek: 40' x 2,300' x 11,500' (mean); Marcus Hook: 40' x 2,300' x 13,650' (mean); Deepwater Point: 40' x 2,300' x 5,200' (mean); Reedy Point: 40' x 2,300' x 8,000' (mean); Port Richmond: 37' x 500' (mean) x 6,400'; and, Gloucester: 30' x 400' (mean) x 3,500'. Mantua Creek anchorage is currently maintained to about 60% of the authorized width and a 37-foot depth. The Marcus Hook anchorage, enlarged in 1964, is maintained to the authorized dimensions. The anchorage at Port Richmond is about 35 feet deep,

¹ All depths refer to mean low water.

as are the Reedy Point and Deepwater Point anchorages. The Gloucester anchorage requires no dredging and is currently deeper than authorized. See Figure 1 for map of the project location.

The existing authorized channel is maintained by USACE at 40 feet and is routinely dredged. There are wide variations in the amount of dredging required to maintain the Philadelphia to the Sea project. Some ranges are nearly self-maintaining and others experience rapid shoaling. The 40-foot channel requires annual maintenance dredging in the amount of approximately 3,455,000 cubic yards. Of this amount, the majority of material is removed from the Marcus Hook (44%), Deepwater Point (18%) and New Castle (23%) ranges. The remaining 15 percent of material is spread throughout the other 37 channel ranges. The historic annual maintenance quantities for the Marcus Hook and Mantua Creek anchorages are 487,000 and 157,000 cubic yards, respectively.

There are currently seven upland sites in the riverine portion of the project and one open-water site, located in Delaware Bay, that are used for dredged material disposal. The seven confined upland sites are National Park, Oldmans, Pedricktown North, Pedricktown South, Penns Neck, Killcohook and Artificial Island. The open water site in Delaware Bay is located in the vicinity of Buoy 10. This site is only approved for placement of sand and is only used for disposal of material removed from the Bay (Reaches D and E).

2.2 ESA Consultation on USACE Maintenance of the Existing Channel

In September 1986, the USACE Philadelphia District (hereafter Philadelphia District) initiated formal consultation under Section 7 of the ESA, with regard to maintenance dredging of Delaware River Federal Navigation Projects from Trenton to the Sea, and potential impacts to the Federally endangered shortnose sturgeon (*Acipenser brevirostrum*). “A Biological Assessment of Shortnose Sturgeon (*Acipenser brevirostrum*) Population in the Upper Tidal Delaware River: Potential Impacts of Maintenance Dredging” was provided to NMFS with the initiation request. It was determined by the USACE that maintenance dredging activities in the southern reaches of the Delaware River, specifically from Philadelphia to the Sea, were not likely to adversely affect shortnose sturgeon. In a letter dated June 17, 1994 we provided concurrence with this determination.

In September 1995, consultation was reinitiated regarding potential impacts associated with dredging projects permitted, funded or conducted by the Philadelphia District. This batched consultation was to consider effects of the following actions on NMFS listed species: maintenance of the Philadelphia to Trenton Federal navigation channel, maintenance of the Philadelphia to the Sea Federal navigation channel, several beach nourishment projects which used sand dredged from Delaware Bay and authorized borrow areas located along the New Jersey and Delaware coasts, and dredging projects conducted by private applicants and authorized by the USACE through their regulatory authority under Section 10 of the Rivers and Harbors Act. “A Biological Assessment of Federally Listed Threatened and Endangered Species of Sea Turtles, Whales, and the Shortnose Sturgeon within Philadelphia District Boundaries: Potential Impacts of Dredging Activities” was provided to us for review. An Opinion was issued by us on November 26, 1996 which considered effects of all projects conducted or authorized by the USACE in the Philadelphia District. The Opinion concluded that the Philadelphia District’s

dredging program, including maintenance of the Philadelphia to the Sea and Philadelphia to Trenton navigation projects, may adversely affect sea turtles and shortnose sturgeon, but was not likely to jeopardize the continued existence of any threatened or endangered species under our jurisdiction. The Opinion included an Incidental Take Statement (ITS) which exempted the annual take by injury or mortality of three shortnose sturgeon. This Opinion was amended with a revised ITS on May 25, 1999. The amended take statement issued on May 25, 1999 exempts the annual take of up to four shortnose sturgeon and four loggerhead sea turtles or one Kemp’s ridley or one green sea turtle.



Figure 1: Illustration of the Deepening Project. Figure provided by USACE Philadelphia District.

2.3 Channel Deepening Proposal and Consultation History

In 1983, the Philadelphia district was directed by Congress to begin feasibility studies regarding modifying the existing 40-foot Delaware River main shipping channel. In 1992, a final feasibility report recommended that the channel be deepened to 45 feet. Congress authorized the deepening project for construction in 1992. The project would involve deepening the main channel of the Delaware River from 40 to 45 feet from Philadelphia Harbor, PA and the Joseph A. Balzano Marine Terminal (formerly, the Beckett Street Terminal), Camden, NJ to the mouth of the Delaware Bay as well as the widening of 12 of the 16 bends in the channel and deepening the Marcus Hook Anchorage. It was anticipated that the project would result in the removal of approximately 26 million cubic yards (CY) of material.

An Environmental Impact Statement (EIS) for this project was issued in 1992, a supplemental EIS was issued in 1997 and a Record of Decision (ROD) was signed in 1998. We provided comments to the USACE on the EIS and SEIS in letters dated March 1, 1995, February 14, 1997 and September 29, 1997.

In May 2000, the Philadelphia District submitted a BA and request for consultation considering the effects of proposed rock blasting in the Marcus Hook range of the main channel deepening project on shortnose sturgeon. On January 31, 2001, we issued an Opinion which concluded that rock blasting conducted from December 1 to March 15 may adversely affect, but is not likely to jeopardize the continued existence of shortnose sturgeon. The Opinion included an ITS that exempts the lethal take of 2 shortnose sturgeon and an unquantifiable amount of non-lethal take. The ITS included reasonable and prudent measures and terms and conditions including a time of year restriction, reporting requirements, and other measures to minimize the potential for injury or mortality of shortnose sturgeon during blasting operations.

Planning for the deepening project was suspended in 2002 as a result of a review by the Government Accountability Office (GAO) regarding the economic benefits of the project and the environmental impacts. In May 2007, the Philadelphia Regional Port Authority (PRPA) took over sponsorship of this project from the Delaware River Port Authority. In June 2008, the USACE and the PRPA executed a Project Partnership Agreement for construction of the Delaware Main Stem and Channel Deepening Project from 40 feet to 45 feet. In December 2008, we were notified that the project was reactivated. A Public Notice was posted on the Philadelphia District's website on December 18, 2008, announcing that the Philadelphia District would conduct an environmental review of all applicable, existing and new information generated subsequent to the 1997 SEIS. We commented on that notice in a letter dated December 30, 2008. Also in this letter, we indicated that upon review of the project materials, it appeared that reinitiation of the 1996 and 2001 consultations was appropriate.

Reinitiation of consultation is required if: “(a) the amount or extent of taking specified in the ITS is exceeded; (b) 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; (c) any of the identified actions are subsequently modified in a manner that causes an effect to the listed species that was not considered in the BO; or (d) a new species is listed or critical habitat

designated that may be affected by the identified actions” (50 CFR 402.16).

As noted above, on November 26, 1996, we issued a Biological Opinion to the Philadelphia District, which concluded that maintenance dredging operations within the Philadelphia District were not likely to jeopardize the continued existence of any threatened or endangered species listed under our jurisdiction. Following the exceedance of the ITS in 1998, on May 25, 1999, in response to the authorized take level being exceeded, consultation was reinitiated and we amended the existing consultation with a revised ITS. Consultation on the blasting portion of the project had been completed in February 2001. As noted in our December 2008 letter, there was new information that indicated that the proposed deepening may have effects to listed species in a manner or to an extent not previously considered. This information included new information on the distribution and seasonal movements of shortnose sturgeon in the Delaware River as well as new information on the vulnerability of the species to capture in mechanical dredges and entrainment in hydraulic hopper dredges. Additionally, the project had been modified from the proposal outlined in the 1992 EIS and 1997 SEIS. Modifications included changes to the amount of material to be removed in the initial dredge cycle as well as in maintenance dredging, plans for beneficial reuse of the material, and the anticipated schedule for completion.

On January 26, 2009, we received a letter from the USACE requesting the initiation of consultation regarding the effects of the proposed deepening on listed species. Supplemental information was provided by the USACE on February 9, 2009. Also sent in February 2009 was a letter from the USACE clarifying that the scope of the proposed action under consultation was the initial dredge cycle necessary to deepen the channel to 45 feet, including blasting at Marcus Hook, collectively referred to as the “construction” phase of the project, and 10 years of USACE planned maintenance dredging. On March 12, 2009, a revised project schedule was provided to us by the USACE and on April 3, 2009 a final Environmental Assessment (EA) was distributed by the USACE. Consultation was initiated on February 9, 2009.

A Biological Opinion was signed by us on July 17, 2009. In this Opinion, NMFS considered the effects of the proposed deepening project, including blasting and dredging, on listed sea turtles and shortnose sturgeon. By issuing the 2009 Opinion, we withdrew the 2001 Opinion on blasting. The first phase of the deepening, in Reach C, occurred from March – September 2010. No interactions with any ESA listed species under our jurisdiction were observed.

In October 2010, we published two proposed rules to list five Distinct Population Segments (DPS) of Atlantic sturgeon. During the winter of 2010-2011, we discussed potential impacts of the deepening project on Atlantic sturgeon with the USACE. In March 2011, USACE completed a supplemental BA considering effects of the deepening on the proposed New York Bight DPS of Atlantic sturgeon. This BA was transmitted to us along with a request to conduct a conference to consider the effects of the proposed deepening on Atlantic sturgeon. In June 2011, the USACE published a draft supplemental EA. In an August 15, 2011, letter we provide the USACE with technical assistance regarding upcoming dredging of Reach B. USACE published a final EA in September 2011. Dredging in Reach B was carried out in November and December 2011, with no observations of interactions with any NMFS listed species. In March 2012, we received USACE reports on the tracking of tagged Atlantic and shortnose sturgeon during the dredging as

well as a report on pre- and post-dredge substrate sampling.

On February 6, 2012, we published two final rules listing five DPSs of Atlantic sturgeon as threatened or endangered. As described in a letter dated May 3, 2012, we reinitiated the 2009 consultation to consider effects of the deepening project on Atlantic sturgeon. Consultation was reinitiated on April 6, 2012. We provided a draft of this Opinion to the USACE on June 22, 2012. Comments were received on July 2 and July 3, 2012. These comments were addressed as appropriate. We issued a final opinion on July 11 2012; by issuing that Opinion, we withdrew the Opinion dated July 17, 2009.

Our 2012 Biological Opinion included an Incidental Take Statement with Reasonable and Prudent Measures and Terms and Conditions. To implement RPM #9, USACE was required to submit to us a plan outlining the measures they will take to ensure that no shortnose or Atlantic sturgeon are present within 500 feet of the detonation site. The Term and Condition states that the plan may involve the use of an underwater imaging system (sonar fish finder, DIDSON, video etc.) to document the presence of fish in the area surrounding the blast site or could involve relocation trawling. In December 2013, USACE submitted a request to reinitiate consultation to consider effects of a relocation trawling pilot study. We considered the effects of this activity in a January 2014 Biological Opinion. The 2014 Opinion also considered the effects of additional deepening of the Reedy Island Range (to 50 feet) to support the Oakwood Beach Storm Damage Reduction project.

The pilot study, conducted in February-April 2014, demonstrated that sturgeon can be effectively captured in the Marcus Hook area using commercial trawling gear and safely moved to a remote release location. More information on the pilot study is presented below (add section number). USACE also conducted a study in March-May 2015 to test the feasibility of using underwater sound to behaviorally exclude sturgeon from the blasting area. We considered effects of the sound deterrence pilot in a February 15, 2015 letter. This letter served as an amendment to the 2014 Opinion.

In the summer of 2015, USACE informed us of changes to the proposed blasting project. Due to the potential delay of blasting operations in the Marcus Hook area, that may be caused by ice, USACE has determined that blasting may need to occur over two winters. The 2014 Opinion only evaluated the effects of blasting occurring over one winter (December 1 – March 15). USACE is also proposing relocation trawling prior to and during the blasting at Marcus Hook and the use of a sound deterrent to attempt to minimize the number of sturgeon exposed to effects of blasting. In addition, new information available since the 2014 Opinion suggests that more shortnose and Atlantic sturgeon may be present in the Marcus Hook area during the winter than considered in previous Opinions. Therefore, reinitiation is necessary to (1) consider new information revealing effects of the action that may affect listed species in a manner or to an extent not previously considered; and (2) because the action will be modified in a manner causing effects to ESA listed species not previously considered.

Consultation was reinitiated on August 20, 2015. By issuing this new Opinion, we withdraw the Opinion dated January 31, 2014.

3.0 DESCRIPTION OF THE PROPOSED ACTION

3.1 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 for this consultation includes the area affected by dredging and disposal activities as well as the area transited by project vessels. The action area also includes the area where relocation trawling will occur (in Marcus Hook) and the area where sturgeon will be relocated to (Mifflin Range, Torresdale Range and Keystone Channel, all located within 48 km upriver of Marcus Hook). The action area, therefore, includes the entirety of the Philadelphia to the Sea Federal navigation channel, including the authorized anchorages and bends to be widened as well as areas within or adjacent to the channel where sturgeon will be relocated to during February 2014. Additionally, the action area includes the beneficial use disposal areas at Broadkill Beach and Oakwood Beach. Further, the action area includes the areas where project vessels will transit to offload dredged material at the upland disposal areas, which is limited to the navigation channel and adjacent berthing areas. The action area will also encompass the underwater area where dredging will result in increased suspended sediment and where sound pressure waves associated with blasting will be experienced. The size of the sediment plume will vary depending on the type of dredge used and is detailed below. Effects of blasting are expected to be limited to an area with a radius of 500 feet around the detonation site. The action area is illustrated in Figure 1, and is largely consistent with the Philadelphia to the Sea navigation channel, with the extension upstream including the areas where sturgeon will be relocated to in the winters (December 1 – March 15) of 2015-2016 and 2016-2017.

3.1.1 Physical Characteristics of the Action Area

The Delaware River Estuary is 212 km (132 miles) long and extends from Cape May and Cape Henlopen to Trenton, New Jersey. The region of the estuary that is referred to as Delaware Bay is 45 miles long and extends from the Capes to a line between stone markers located at Liston Point, Delaware and Hope Creek, New Jersey (Polis *et al.* 1973). The estuary varies in width from 17.7 km at the Capes; to 43 km at its widest point (near Miah Maull Shoal). Water depth in the bay is less than 30 feet deep in 80 percent of the bay and is less than 10 feet deep in much of the tidal river area.

Artificial Island is located approximately 3.2 km upstream of the hypothetical line demarking the head of Delaware Bay. The tidal river in this area narrows upstream of Artificial Island and makes a bend of nearly 60 degrees. Both the narrowing and bend are accentuated by the presence of Artificial Island. More than half of the typical river width in this area is relatively shallow, less than 18 feet (5.5 meters), while the deeper part, including the dredged channel has depths of up to 40 feet (12.1 meters). The Delaware River between the fall line at Trenton (RM 138 (rkm 222)) and Philadelphia (RM 100 (rkm 161)) is tidal freshwater with semidiurnal tides. Mean tidal range at Philadelphia 5.9 ft. (1.8 m) (U.S. Army Engineer District, 1975); water pH generally is about 6-8.

Tidal flow as measured near the Delaware Memorial Bridge (rkm 108), 32 kilometers above Artificial Island, was measured at 399,710 cfs (11,320 cubic meters per second) (USGS, 1966).

Tidal flow of this magnitude is 17 times as great as the total average freshwater flow rate into the estuary. Proceeding toward the mouth of the estuary, tidal flow increasingly dominates freshwater downstream flow; proceeding upstream from the Delaware Memorial Bridge, the ratio of tidal flow to net downstream flow becomes smaller as tidal influence decreases.

3.2 Proposed Deepening Project

The deepening project as authorized by Congress (shown on Figure 1) provides for modifying the existing Delaware River Federal Navigation channel Philadelphia to the Sea Project from 40 to 45 feet at Mean Low Water with an allowable dredging overdepth of one foot, following the existing channel alignment from Delaware Bay to Philadelphia Harbor, Pennsylvania and the Joseph A. Balzano Terminal, Camden, New Jersey. The channel side slopes are 3 horizontal to 1 vertical. The project also includes deepening of an existing Federal access channel at a 45-foot depth to the Joseph A. Balzano Terminal, Camden, New Jersey. The channel is divided into six reaches as shown in Table 1. The lowermost end of Reach E is located approximately 8 km from the theoretical line between Cape Henlopen and Cape May Point.

Table 1: Description of Delaware River Channel Reaches

Reach	River Miles	River Kilometers
AA	102-97.1	164-156.3
A	97-85.1	156.2-137.1
B	85-67.1	137-108.1
C	67-55.1	108-88.6
D	55-41.1	88.5-66.1
E	41-5	66-8

The existing channel is maintained at a depth of 40 feet deep at mean low water (MLW). Only portions of the channel that are currently between 40 feet and 45 feet MLW will be dredged for the deepening project. The surface area of the Delaware estuary from the Ben Franklin Bridge to the capes (excluding tidal tributaries) is approximately 700 square miles. The Philadelphia to the Sea Federal navigation channel has a surface area of 15.3 square miles, or approximately 2.2 percent of the total estuary surface area. For the 45-foot deepening project, 8.5 square miles will be dredged; this is 1.2 percent of the total estuary surface area and 55 percent of the existing channel. At this time, 6.2 square miles have already been deepened. The remaining 6.8 square miles of the existing channel is already 45 feet deep or deeper. See Table 2 (below) for a description of the amount of material to be removed from each channel range.

The channel width (same as the existing 40-foot project) is 400 feet in Philadelphia Harbor (length of 2.5 miles or 4 km); 800 feet from the Philadelphia Navy Yard to Bombay Hook (length of 55.7 miles); and 1,000 feet from Bombay Hook to the mouth of Delaware Bay (length of 44.3 miles or 71.3 km). The project includes 12 bend widenings at various ranges as listed below as well as provision of a two space anchorage to a depth of 45 feet at Marcus Hook, Pennsylvania. The existing turning basin adjacent to the former Philadelphia Naval Shipyard will not be deepened as part of the 45 foot project.

Also included as part of the Federal project is the relocation and addition of navigation buoys at the 12 modified channel bends. Ten new buoys are proposed: Philadelphia Harbor (2), Tinicum Range (1), Eddystone Range (1), Bellevue Range (3), Cherry Island Range (1), Bulkhead Bar Range (1), and Liston Range (1).

The following channel bends will be modified (described modifications will be maintained in the future):

1. MIAH MAULL-CROSS LEDGE: 200 foot width increase at the apex of the west side of the bend (part of Upper Reach E contract);
2. BELLEVUE-MARCUS HOOK: The east apex of the bend requires a 150 foot widening over existing conditions, along a total length of approximately 4,000 feet (BW7 - channel station 141 + 459)(part of Reach B contract);
3. CHESTER-EDDYSTONE: The southwest apex of the bend requires a maximum 225 foot widening, with a transition to zero at the northeast end of Eddystone range, over a linear distance of approximately 6,000 feet (BW8 - channel station 104 + 545)(part of Reach B contract);
4. EDDYSTONE-TINICUM: The northeast apex of this bend requires a 200 foot widening, with a transition to zero at a distance of about 1,200 feet northeast and southwest of the bend apex (BW9 - channel station 97 + 983)(part of Reach B contract);
5. TINICUM-BILLINGSPORT: The north channel edge of Billingsport was widened by 200 feet. At the northern apex of the Tinicum-Billingsport bend, this results in a maximum widening of approximately 400 feet, with a transition to zero at a distance of about 2,000 feet west of the apex (BW10 - channel station 79 + 567)(part of Reach B contract).

The following channel bends modifications have been completed to date (described modifications will be maintained in the future):

1. LISTON-BAKER: Maximum width increase on the east edge of 250 feet, over a distance of 4,500 feet south of the apex, and extending 3,900 feet north from the apex (BW2 – channel station 275 + 057);
2. BAKER-REEDY ISLAND: 100-foot width increase at the west edge apex of the bend over a distance of 3500 feet both north of and south of the apex (BW3 - channel station 265 + 035);
3. REEDY ISLAND-NEW CASTLE: Maximum widening of 400 feet at the west apex of the bend, tapering to zero over a distance of 3,200 feet south of the apex and to zero over a distance of 4,000 feet north of the apex (BW4 - channel station 238 +982);
4. NEW CASTLE-BULKHEAD BAR AND BULKHEAD BAR-DEEPWATER: The west edge of Bulkhead Bar range is extended by 300 feet to the south and 300 feet to the north; the widening tapers to zero at a distance of approximately 3,000 feet south of the south end of Bulkhead Bar and 3,000 feet north of the north end of Bulkhead bar (BW5 - channel station 212 + 592 and 209 + 201);

5. DEEPWATER-CHERRY ISLAND: A maximum channel widening of 375 feet is required at the western apex of the bend. The widening tapers to zero at a distance of about 2,000 feet both north and south of the apex (BW6 - channel station 186 + 331);
6. BILLINGSPORT-MIFFLIN: The south apex of the bend was widened a maximum of 200 feet to the south, and transitioned to zero at a distance of approximately 3,000 feet northeast of the apex (BW11 - channel station 72 + 574);
7. EAGLE POINT-HORSESHOE BEND: The northwest edge of Horseshoe Bend requires a maximum widening of 490 feet to the north. The widening transitions to zero at a distance of approximately 4,000 lineal feet west of the west end of Horseshoe Bend, and at a distance of 1,500 lineal feet north of the north end of the bend (BW12 - channel station 44 + 820 to 41 + 217).

The current dredged material disposal plan for the riverine portion of the project will utilize the existing upland Federal disposal sites (National Park, Oldmans, Pedricktown North, Pedricktown South, Killcohook, Reedy Point South, and Artificial Island). In Delaware Bay, material will be used for beneficial use projects at Broadkill Beach and Oakwood Beach. The Kelly Island project, which was considered in earlier Opinions, is no longer being pursued.

3.2.1 Initial Dredging Cycle

For the initial deepening (not including maintenance dredging), approximately 16 million cubic yards (cy) of material will be dredged and placed by hydraulic cutter-suction (pipeline) and hopper dredges in confined upland disposal facilities in the Delaware River portion of the project area and for beneficial uses in Delaware Bay (See Table 2 for remaining deepening work). In addition, approximately 250,000 cubic yards of rock will be removed in the vicinity of Marcus Hook, Pennsylvania and placed in the Fort Mifflin confined disposal facility in Philadelphia. Blasting will be used in this area, followed by removal of rocky material with a mechanical dredge.

Initial deepening activities began in March 2010. Deepening is currently scheduled to continue through December 2017. To date, six construction contracts have been awarded and completed (Reach C, Lower Reach B, Upper Reach A, Reach D, Lower Reach A, and Reach AA). The seventh contract awarded (Lower Reach E – Broadkill Beach) is approximately 50% complete. A summary of the proposed dredging remaining to be completed is shown in Table 2. As noted in Table 2, several different types of dredges will be used for deepening activities. The “Type of Dredge” column indicates the type of dredge (or dredges) most likely to be used for each contract; however, with few exceptions, the actual type of dredge used for each contract will be determined by the dredging contractor.

Table 2: Summary of initial dredging quantities (remaining work as of October 2015)

Channel Reach	River kilometer (rkm)	Duration (Months)	Volume (CY)	Type of Dredge	Scheduled Dates²
Contract 7 – Lower Reach E (Broadkill Beach)	25.1	18	2,100,000	hopper	September 2014–April 2016
Contract 8 – Reach B (Rock Removal: Blasting and Clean Up Dredging)	123 – 136.2	15	250,000	mechanical	December 2015 – December 2017 (work to occur December 1 – March 15 of each year only)
Contract 9 – Upper Reach E (Artificial Island Confined Disposal Facility)	49.6 – 58.6	8	1,000,000	hopper	April – December 2016
Contract 10 – Upper Reach B	136.8 – 107.8	7.5	3,485,469	cutterhead	August 1, 2016 – March 15, 2017

Reach E is considered to be in Delaware Bay. Table 2 shows the currently proposed construction schedule and the type of dredge that would be used for different sections of the river for the Deepening Project as provided by USACE. USACE has indicated that the dredging plan was, to the extent practicable, developed to be in compliance with the Delaware River Basin Fish and Wildlife Management Cooperative recommended dredging restrictions for protection of fishery resources in the Delaware River and Bay.

3.2.3 Description of Dredge Equipment

Three types of dredges will be used: hopper, hydraulic cutterhead, and mechanical. Brief descriptions of the operations of this equipment are presented below.

Self-Propelled Hopper Dredges

Hopper dredges are typically self-propelled seagoing vessels. They are equipped with propulsion machinery, sediment containers (i.e., hoppers), dredge pumps, and other specialized equipment required to excavate sediments from the channel bottom. Hopper dredges have propulsion power adequate for required free-running speed and dredging against strong currents.

A hopper dredge removes material from the bottom of the channel in thin layers, usually 2-12 inches, depending on the density and cohesiveness of the dredged material (Taylor 1990). Pumps within the hull, but sometimes mounted on the dragarm, create a region of low pressure around the dragheads; this forces water and sediment up the dragarm and into the hopper. The more closely the draghead is maintained in contact with the sediment, the more efficient the dredging

² Schedule is subject to change based on available funding.

(i.e., the greater the concentration of sediment pumped into the hopper). In the hopper, the slurry mixture of sediment and water is managed to settle out the dredged material solids and overflow the supernatant water. When a full load is achieved, the vessel suspends dredging, the dragarms are heaved aboard, and the dredge travels to the dredge material disposal site. Hopper dredges are being used in lower Reach E, with placement of the dredged sand at Broadkill Beach. A hopper dredge will most likely be used for the upper Reach E contract, as well.

Bucket Dredges

The bucket dredge is a mechanical device that utilizes a bucket to excavate the material to be dredged. The dredged material is placed in scows or hopper barges that are towed or pushed to the placement site. Bucket dredges include the clamshell, orange-peel, and dragline types. The crane that operates the bucket can be mounted on a flat-bottomed barge, on fixed-shore installations, or on a crawler mount. In most cases, spuds, or anchors and spuds are used to position the plant. Because the bucket dredge loads scows or hopper barges, work is suspended when a fully loaded barge is moved away and replaced with another empty scow or barge. Spuds are typically employed to maintain the position of a floating bucket dredge plant. A mechanical dredge will be used to remove debris following blasting in Reach B.

Hydraulic Cutterhead Pipeline Dredges

The cutterhead dredge is essentially a barge hull with a moveable rotating cutter apparatus surrounding the intake of a suction pipe (Taylor 1990). By combining the mechanical cutting action with the hydraulic suction, the hydraulic cutterhead has the capability of efficiently dredging a wide range of material, including clay, silt, sand, and gravel.

The largest hydraulic cutterhead dredges have 30 to 42 inch diameter pumps with 15,000 to 20,000 horsepower. The dredge used for this project is expected to have a pump and pipeline with approximately 30" diameter. These dredges are capable of pumping certain types of material through as much as 5-6 miles of pipeline, though up to 3 miles is more typical. The cutterhead pipeline plant employs spuds and anchors in a manner similar to floating mechanical dredges. A cutterhead dredge is likely to be used in Reach B.

Rock Blasting

Approximately 250,000 cubic yards of bedrock and overburden material (i.e., rock debris resulting from the blasting, which will fracture the rock) from 18 acres in Reach B near Marcus Hook, PA (RM 76.4 to 84.6) will be removed to deepen the navigation channel to a depth of 45 feet below mean lower low water. Rock will be placed in the Fort Mifflin dredged material disposal site located in Philadelphia. In order to remove the rock by blasting, holes drilled into the rock will be packed with explosive at the bottom of the holes and the remainder of the drill-hole filled with inert stemming material to the surface in order to direct the force of the blast into the rock. The depth and placement of the holes along with the size and blast timing delays of the charges will be carefully controlled so that the amount of rock that is broken and energy levels released during the blasting operations is limited to the level required only to break up the bedrock. The project would be conducted by repeatedly drilling, blasting, and excavating relatively small areas until the required cross section of bedrock is removed. Blasting operations will occur between December 1 and March 15, with no more than two blasts conducted per day.

The broken and pulverized rock along with overlying sands and silts will be removed by a mechanical dredge. Because the rock that will be blasted is bedrock, the areas that undergo blasting will retain the same substrate characteristics following the completion of this project. Blasting and clean up dredging (i.e., clearing blasting debris to ensure 45 foot depth) is scheduled to occur between December 1, 2015 and March 15, 2016 and again between December 1, 2016 and March 15, 2017.

USACE has built several measures into the proposed action designed to minimize the effects of blasting on fish. These include plans to:

- Perform relocation trawling before and during blasting activities;
- Use acoustic deterrent system prior to detonation events;
- Minimize the size of explosive charges per delay (time lag during detonation) and the number of days of explosive exposure;
- Subdivide the explosives deployment, using suitable detonating caps with delays or delay connectors for detonation cord, to reduce the seismic energy and total pressure changes induced by the blasting;
- Use decking (explosives separated by delays) in drill holes to reduce total pressure changes;
- Use angular stemming material in the blasting holes above the explosive charges (specifically sized angular rock fragments backfilled in the drill holes to contain the explosive energy and reducing the unwanted effects of a pressure waves emanating from the blast and flyrock) ;
- Use scare charges for each blast; and,
- Monitor impacts to fish from blasting.

Specifically, relocation trawling will be initiated in mid-November 2015 and 2016 approximately two weeks prior to the anticipated start of blasting operations on December 1, 2015 and 2016. Initial trawling efforts will attempt to remove as many sturgeon as possible from the blasting area. Trawling will be performed every other day during blasting to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver. The acoustic deterrent system will be an Applied Acoustic Engineering Ltd. (AAE) “boomer” that will produce a low frequency sound of less than or equal to 204 dB re 1 μ Pa peak at a repetition of 20 booms per minute for at least 5 hours prior to each detonation. For more details on relocation and acoustic deterrence, see Sections 3.5.1 and 3.5.2.

For each blast, USACE proposes to monitor an area with a radius of 500 feet surrounding the detonation site with sonar or other imaging techniques designed to document fish in this area. Surveys will begin 20 minutes prior to the blast and if any fish are observed in the monitoring zone, blasting will be delayed until the fish leave the area. Additionally, two scare charges shall be used before each blast. The scare charges shall be detonated in close proximity to each blast. Each individual scare charge shall not exceed a TNT-equivalent weight of 0.1 lb. The detonation of the first scare charge will be 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. USACE will also monitor blast pressures and upper limits will be imposed on each series of 5 blasts so that average peak pressure shall not exceed 70 pounds per square inch (psi) at a distance of 140 feet and maximum peak pressure shall not exceed 120 psi at a distance of 140 feet.

3.3 Dredged Material Disposal

As stated above, over the life of this project, you anticipate that approximately 16 million cy of material will be removed from the channel to deepen it from 40 to 45 feet. Approximately 6,835,469 cy remain to be removed. All material removed from Reach B and upper Reach E, regardless of dredge type, will be disposed of at the Artificial Island CDF. Approximately 2.1 million cy of suitable material removed from the channel in lower Reach E will be used for beach nourishment at Broadkill Beach. Periodic (approximately every eight years) removal of sand from a 3 km section of the navigation channel extending from the northern point of Reedy Island (Reach D) will be dredged for nourishment of Oakwood Beach. This work will maintain depths in this area between 45 and 50 feet. Descriptions of the proposed beneficial use sites are provided in Sections 3.3.2 and 3.3.3, below.

3.3.1 Upland Disposal

Approximately 1,000,000 cy of dredge material removed by a hopper dredge from upper Reach E (RM 30.8-36.4) will be deposited at the Artificial Island CDF (RM 53) from April to December 2016.

Rock removed following blasting in Reach B will be transported to Ft. Mifflin (RM 91.3) or Predricktown CDF (RM 76.4), and material dredged from Reach B using a cutterhead dredge will be pumped directly to Oldman's (RM 75.2) or Predricktown CDF.

3.3.2 Broadkill Beach (Delaware)

The Delaware Bay Coastline, DE & NJ – Broadkill Beach, DE project was authorized for construction by Title I, Section 101 (a) (11) of the Water Resources Development Act of 1999. The Delaware Department of Natural Resources and Environmental Control is the non-Federal project sponsor. The project area is located along the Delaware Bay Coastline at Broadkill Beach, Sussex County, Delaware. The authorized plan for this project has the following components:

- A berm extending seaward 100 feet from the design line at an elevation of +8 ft NGVD. The beachfill extends from Alaska Avenue southward for 13,100 linear feet. Tapers of 1,000 feet extending from the northern project limit and 500 feet extending from the southern project limit brings the total project length to 14,600 linear feet.
- On top of the berm lies a dune with a top elevation of +16 ft. NGVD and a top width of 25 feet.
- A total initial volume of 1,598,700 cubic yards of sand fill would be placed along the area. This fill volume includes initial design fill requirements and advanced nourishment.
- Periodic nourishment of 358,400 cubic yards of sand fill would be placed every 5 years.
- Planting of 174,800 square yards of dune grass and 21,800 linear feet of sand fence are included for dune stability.
- Vehicular access to the beach would be provided at Route 16 in the center of Broadkill Beach. Sand fence would be used to create a path 12 feet wide along both sides of the dune at a skewed angle to the dune alignment. This would allow vehicles to climb along the side of the dune at a flatter slope than 5H:1V.

- Pedestrian access paths would be located at each street end in a similar fashion as the vehicular access. However, the access paths would be smaller in width and at a somewhat steeper slope.

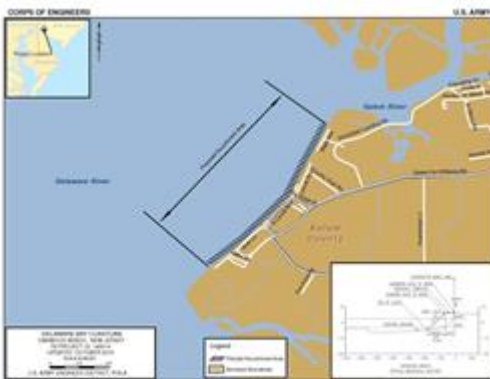
Dredging and disposal at Broadkill Beach has been executed as Contract No. 7. Construction commenced in April 2015 and is currently scheduled for completion in April 2016.

3.3.3 Oakwood Beach (Delaware)

The Delaware Bay Coastline, DE & NJ – Oakwood Beach Hurricane and Storm Damage Reduction Project was authorized for construction by Title I, Section 101 (a) (11) of the Water Resources Development Act of 1999. The New Jersey Department of Natural Resources and Environmental Control is the non-Federal project sponsor. The project area is located along the eastern Delaware Bay Coastline at Elsinboro Township, Salem County, New Jersey (see Figure below). The authorized plan for this project has the following components:

- A 50-foot berm at an elevation of +6.0 feet NAVD for a total length of 9,500 feet. On top of the berm lies a dune with a top elevation of +16 feet NGVD and a top width of 25 feet.
- Extension of five stormwater outfall pipes to be supported by timber cribbing mounted on 20-foot long 12-inch diameter piles spaced 18-feet apart.
- Placement of 354,000 cubic yards of sand on Oakwood Beach for initial nourishment.
- Periodic nourishment of 33,000 cubic yards of sand fill would be placed every 8 years.

To obtain the sand necessary for this project, USACE deepened a three km section of the navigation channel extending from the northern point of Reedy Island (within Reach D). This area has already been deepened to 45 feet and the additional dredging brought it to 50 feet. Periodic (approximately every eight years) removal of sand from this area for subsequent nourishment of Oakwood Beach will maintain depths in this area between 45 and 50 feet. Dredging and disposal for initial construction of Oakwood Beach occurred between November 2014 and May 2015.



3.4 Maintenance Dredging

The required maintenance dredging of the 45-foot channel will increase by 862,000 cubic yards per year (cy/yr) from the current 3,455,000 average cy/yr for the 40-foot channel for a total of 4,317,000 cy/yr. Only areas shallower than 45 feet will be dredged during maintenance activities.

Maintenance dredging in the river (Reaches AA – C) usually takes place over an approximately 2 month period between August and December primarily using a hydraulic cutterhead dredge; however, a hopper dredge may occasionally be used for this work. Approximately 3,845,000 cy of material will be removed from the river annually, with the majority of material removed from the Marcus Hook, Deepwater and New Castle ranges. All material excavated from the river portion of the project will continue to be placed in existing approved upland disposal areas. The timing and duration of maintenance dredging in the Bay varies but typically occurs in the summer and fall. On average, approximately 472,000 cy of material will be removed from the bay annually. Dredging in this area is done using a hopper dredge with open water disposal (at Buoy 10). As explained above, the proposed action under consideration in this consultation includes annual maintenance dredging through 2027. Maintenance dredging can begin as soon as the year after deepening begins, depending on the rate of sedimentation in a particular reach, which is influenced by river morphology, sediment type and natural conditions such as tides, currents and storms. Maintenance dredging has begun in Reaches C, D and portions of A and B. Dredging in lower Reach E started in April 2015 and continued through the end of August 2015. Dredging is expected to recommence in November 2015 and continue through April 2016. The total amount dredged to date is approximately 900,000 CY. The amount remaining is approximately 1,000,000 CY. Maintenance dredging of upper Reach E will commence following completion of the lower portion.

3.5 Capture, Relocation, and Deterrence of Sturgeon during Blasting

The environmental window for blasting is December 1 through March 15. Accordingly, sturgeon relocation will be performed in approximately the same period. Table 3 provides a summary of proposed sturgeon monitoring and protection (detailed information is presented below the table):

Table 3: Summary and Schedule of Sturgeon Monitoring and Protection

Task	Schedule
Relocation trawling	Two weeks intensive trawling immediately prior to start of blasting. Additional trawling nominally every other day during blasting period. Trawling schedule and intensity to be modified, as necessary, based on tracking of acoustically tagged sturgeon (see details below).
Blast pressure monitoring	During first three detonations.
Operation of Acoustic Deterrent System	Continuous operation at least five hours before each detonation.
Far-field monitoring of acoustically-tagged sturgeon	Starting two weeks prior to start of blasting and continuously during the blasting period.
Near-field monitoring for acoustically-tagged sturgeon at the blast site	Immediately prior to each detonation.
Near-field monitoring of blast site with DIDSON	Starting 1-2 hours and ending 30 minutes or less before each detonation.

Use scare charges for each blast	Two scare charges, 45 and 30 seconds prior to each blast
Surface monitoring for injured or dead sturgeon	Immediately following each detonation.

3.5.1 Trawling and Relocation

For two weeks prior to the commencement of the two blasting seasons (approximately mid to late November in 2015 and 2016), USACE will trawl intensively in the Marcus Hook blasting area in an attempt to remove as many Atlantic and shortnose sturgeon as possible. The goal of the relocation trawling is to minimize the number of sturgeon present within a 500 foot radius of any detonation. It will not be possible to trawl within the immediate vicinity of a blasting site once the charges are being set. Once blasting begins, trawling will be performed every other day (weather permitting) to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver.

Sturgeon will be collected using a 30.5-m (100-ft) otter trawl fished from a commercial trawler. The specifications for this net are:

Headrope	30.5 m (100 ft)
Footrope	33.5 m (110 ft)
Net body mesh	15.2 cm (6 inch)
Codend mesh	5.4 cm (2 1/8 inch)
Innerliner mesh	2.9 cm (1 1/8 inch)

To reduce snagging, the footrope will be configured with 30-cm (12-inch) disc rollers in the center, graduating to 25.4-cm (10-inch) gumdrops at the wings. The trawl will be towed at a maximum speed of 1.3-1.5 m/sec (2.5-3.0 knots) for 10-15 minutes (actual towing time). A large trawl is being proposed to reduce avoidance and to maximize the area swept per unit time.

Sturgeon will be carefully removed from the net and quickly placed in a floating net pen or on-board tank containing river water at ambient temperature and dissolved oxygen levels. Exposure of the sturgeon to cold air will be minimized to the extent possible. Processing of sturgeon will follow the protocols of Kahn and Mohead (2010). Sturgeon will be identified to species, measured for fork length (FL) and total length (TL) to the nearest millimeter, and weighed to the nearest gram. An approximately 1 cm² piece of pelvic fin will be clipped and retained in ethanol for genetic analysis. Sturgeon of sufficient size will be tagged with a numbered T-bar tag and/or a passive integrated transponder (PIT) tag, and an acoustic transmitter.

A maximum of 100 sturgeon (per blasting season, i.e., 200 total from December 2015 – March 2017) captured by trawl and relocated to upriver release locations will be internally tagged with a VEMCO acoustic transmitter. We expect the 200 sturgeon to be a mix of shortnose and Atlantic sturgeon that will be representative of the ratio of the total sturgeon captured and relocated. (model V7, V9, V13, or V16) matched to the weight of the fish. Tracking acoustically tagged sturgeon following relocation will provide information on the extent and rates at which sturgeon are moving back toward the blasting area. The total weight of tags will not exceed 2% of the

sturgeon's body weight. Sturgeon for acoustic tag implantation will be anesthetized using tricaine methanesulfonate (MS-222) at a dose of 50 mg/L and then held upside down in a cradle where the gills will be perfused with aerated flowing water. The transmitter will be inserted into the body cavity through a small longitudinal incision in the abdomen. The incision will be closed with interrupted sutures of 3-0 polydioxanone (PDS) and treated with povidone iodine (10% solution) and petrolatum to prevent infection.

Depending on the river conditions and safety considerations, sturgeon will be transported to upriver release locations between Burlington (rkm 193) and Roebling (rkm 199), NJ, in a support boat capable of traveling at moderate to high speeds. The release locations, located 55-61 km upriver of the blasting area, are known from previous studies (Brundage and O'Herron, 2010 and 2011; and ERC, 2006a) to have habitat appropriate for sturgeon and to be locations where sturgeon regularly occur. If river icing or other adverse conditions prevent transporting the sturgeon to the Burlington-Roebling area, sturgeon will be transported and released as far upriver as safely possible. Sturgeon will not be transported downriver to preclude releasing them into waters of higher salinity, which could be stressful to younger sturgeon.

During transport, sturgeon will be held in an on-board tank(s) supplied with ambient river water at a rate sufficient to allow for total replacement of water volume every 15 minutes. Dissolved oxygen concentration in the holding tank will be periodically measured using a hand-held meter. Backup oxygenation with compressed oxygen will be provided, if necessary, to ensure sturgeon do not become stressed and dissolved oxygen concentrations remain at or above 4.5 mg/L, consistent with the recommendations in Kahn and Mohead 2010. If an unusually large catch occurs, sturgeon may be held in a floating net pen for a period not to exceed four hours prior to transport.

3.5.2 Acoustic Deterrence

The purpose of the acoustic deterrent system will be to attempt to behaviorally deter sturgeon from entering or remaining in the blasting area. In July 2015, ERC (2015) conducted a feasibility study to test the acoustic deterrent system.

The deterrent system will consist of a sound source capable of producing impulsive sound of the appropriate amplitude and frequency range, and a generator to power the source, mounted on a self-propelled pontoon boat. The sound source will be an Applied Acoustic Engineering Ltd. (AAE) "boomer" typically used for subsurface geophysical profiling (Moody and Van Reenan, 1967). The boomer is an electromagnetically driven sound source consisting of a triggered capacitor bank that discharges through a flat coil. Eddy currents are induced in aluminum plates held against the coil by heavy springs or rubber bumpers. The plates are violently repelled when the capacitor fires, producing a cavitation volume in the water which acts as a source of low-frequency sound (Edgerton and Hayward, 1964).

The sound source will be set to produce a sound level (as determined at 10 m from the source) of ≤ 204 dB re 1 μ Pa peak at a repetition rate of 20/minute; it will also be mounted horizontally such that the sound is projected downward and laterally into the water column below the pontoon boat.

The sound source will be moored as closely to the blasting location as safety and operational considerations allow, and operated continuously for at least five hours prior to each detonation. The sound source will be operated as close in time to the blast as safety allows before being moved away from the blasting site (approximately 30 minutes).

3.5.3 Sturgeon Monitoring during Blasting

The 500 ft. (152 m) radius area surrounding each stemmed charge will be monitored using the DIDSON (high frequency, multi-beam sonar that operates as an “acoustic camera”) 1-2 hours before each detonation (ending 30 minutes or less before detonation). While drifting with the tide or slowly motoring, surveys will be made along upriver-downriver oriented transects spaced 100 ft. (30 m) apart. If a potential sturgeon is observed, the DIDSON will be switched to high-resolution mode and, if necessary, moved closer to determine if the object is a sturgeon. Operators will interpret size, orientation to the bottom, body shape, head and caudal fin shape (if resolution is sufficient), and “Acipenserform” swimming movements. If the object is a sturgeon and remains within the 500 ft. radius blasting area, the blasting contractor will be advised by USACE to delay the detonation until the sturgeon has moved a safe distance away.

Once relocation trawling is initiated, the movements of acoustically tagged sturgeon will be monitored using both passive and active methods. Passive monitoring will be performed using 13 Vemco VR2W single-channel receivers, deployed between rkm 116-143 (Table 2, Fig. 2). These receivers are part of an existing network established and cooperatively maintained by Environmental Research and Consulting, Inc. (ERC) and the Delaware Department of Natural Resources and Environmental Control (DNREC). Far-field monitoring of acoustically tagged sturgeon will be initiated two weeks prior to the start of blasting. The VR2W receivers will be downloaded at least every five days during the blasting period, and the locations and direction of movement of acoustically tagged sturgeon will be plotted. In this method, the locations of acoustically tagged aquatic animals can be determined at a resolution of 2-3 m by post-processing the simultaneous reception of signals from three or more VR2W receivers using a time-difference-of-arrival (TDOA) algorithm (Espinoza *et al.*, 2011). These data will inform USACE about general trends in the movement of relocated and other tagged sturgeon

Active tracking will be conducted with a VEMCO VR100 receiver and an omnidirectional hydrophone in the immediate vicinity of the blasting site immediately prior to detonation to provide warning of tagged sturgeon that may have moved into the area.

4.0 STATUS OF LISTED SPECIES IN THE ACTION AREA

Several species listed under our jurisdiction occur in the action area for this consultation. While listed whales occur seasonally off the Atlantic coast of Delaware and occasional transient right and humpback whales have been documented near the mouth of Delaware Bay, no ESA listed whales are known to occur in the action area. As such, no whale species will be further discussed in this Opinion.

We have determined that the action being considered in this biological opinion may affect the following endangered or threatened species under our jurisdiction:

Sea Turtles

Northwest Atlantic DPS of Loggerhead sea turtle (<i>Caretta caretta</i>)	Threatened
Leatherback sea turtle (<i>Dermochelys coriacea</i>)	Endangered
Kemp's ridley sea turtle (<i>Lepidochelys kempi</i>)	Endangered
Green sea turtle (<i>Chelonia mydas</i>)	Endangered/Threatened ³

Fish

Shortnose sturgeon (<i>Acipenser brevirostrum</i>)	Endangered
Gulf of Maine DPS of Atlantic sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>)	Threatened
New York Bight DPS of Atlantic sturgeon	Endangered
Chesapeake Bay DPS of Atlantic sturgeon	Endangered
South Atlantic DPS of Atlantic sturgeon	Endangered
Carolina DPS of Atlantic sturgeon	Endangered

This section will focus on the status of the various species within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

4.1 Overview of Status of Sea Turtles

With the exception of loggerheads, sea turtles are currently listed under the ESA at the species level rather than as subspecies or distinct population segments (DPS). Therefore, information on the range-wide status of leatherback, Kemp's ridley and green sea turtles is included to provide the status of each species overall. Information on the status of loggerheads will only be presented for the DPS affected by this action. Additional background information on the range-wide status of these species can be found in a number of published documents, including sea turtle status reviews and biological reports (NMFS and USFWS 1995; Hirth 1997; Marine Turtle Expert Working Group [TEWG] 1998, 2000, 2007, 2009; NMFS and USFWS 2007a, 2007b, 2007c, 2007d; Conant *et al.* 2009), and recovery plans for the loggerhead sea turtle (NMFS and USFWS 2008), Kemp's ridley sea turtle (NMFS *et al.* 2011), leatherback sea turtle (NMFS and USFWS 1992, 1998a), Kemp's ridley sea turtle (NMFS *et al.* 2011) and green sea turtle (NMFS and USFWS 1991, 1998b).

2010 BP Deepwater Horizon Oil Spill

The April 20, 2010, explosion of the Deepwater Horizon oil rig affected sea turtles in the Gulf of Mexico. There is an on-going assessment of the long-term effects of the spill on Gulf of Mexico marine life, including sea turtle populations. Following the spill, juvenile Kemp's ridley, green, and loggerhead sea turtles were found in *Sargassum* algae mats in the convergence zones, where currents meet and oil collected. Sea turtles found in these areas were often coated in oil and/or had ingested oil. Approximately 536 live adult and juvenile sea turtles were recovered from the Gulf and brought into rehabilitation centers; of these, 456 were visibly oiled (these and the

³ Pursuant to NMFS regulations at 50 CFR 223.205, the prohibitions of Section 9 of the Endangered Species Act apply to all green turtles, whether endangered or threatened.

following numbers were obtained from <http://www.nmfs.noaa.gov/pr/health/oilspill/>). To date, 469 of the live recovered sea turtles have been successfully returned to the wild, 25 died during rehabilitation, and 42 are still in care but will hopefully be returned to the wild eventually. During the clean-up period, 613 dead sea turtles were recovered in coastal waters or on beaches in Mississippi, Alabama, Louisiana, and the Florida Panhandle. As of February 2011, 478 of these dead turtles had been examined. Many of the examined sea turtles showed indications that they had died as a result of interactions with trawl gear, most likely used in the shrimp fishery, and not as a result of exposure to or ingestion of oil.

During the spring and summer of 2010, nearly 300 sea turtle nests were relocated from the northern Gulf to the east coast of Florida with the goal of preventing hatchlings from entering the oiled waters of the northern Gulf. From these relocated nests, 14,676 sea turtles, including 14,235 loggerheads, 125 Kemp's ridleys, and 316 greens, were ultimately released from Florida beaches.

A thorough assessment of the long-term effects of the spill on sea turtles has not yet been completed. However, the spill resulted in the direct mortality of many sea turtles and may have had sublethal effects or caused environmental damage that will impact other sea turtles into the future. The population level effects of the spill and associated response activity are likely to remain unknown for some period into the future.

4.2 Northwest Atlantic DPS of loggerhead sea turtle

The loggerhead is the most abundant species of sea turtle in U.S. waters. Loggerhead sea turtles are found in temperate and subtropical waters and occupy a range of habitats including offshore waters, continental shelves, bays, estuaries, and lagoons. They are also exposed to a variety of natural and anthropogenic threats in the terrestrial and marine environment.

Listing History

Loggerhead sea turtles were listed as threatened throughout their global range on July 28, 1978. Since that time, several status reviews have been conducted to review the status of the species and make recommendations regarding its ESA listing status. Based on a 2007 5-year status review of the species, which discussed a variety of threats to loggerheads including climate change, we determined with FWS that loggerhead sea turtles should not be delisted or reclassified as endangered. However, we also determined that an analysis and review of the species should be conducted in the future to determine whether DPSs should be identified for the loggerhead (NMFS and USFWS 2007a). Genetic differences exist between loggerhead sea turtles that nest and forage in the different ocean basins (Bowen 2003; Bowen and Karl 2007). Differences in the maternally inherited mitochondrial DNA also exist between loggerhead nesting groups that occur within the same ocean basin (TEWG 2000; Pearce 2001; Bowen 2003; Bowen *et al.* 2005; Shamblin 2007; TEWG 2009; NMFS and USFWS 2008). Site fidelity of females to one or more nesting beaches in an area is believed to account for these genetic differences (TEWG 2000; Bowen 2003).

In part to evaluate those genetic differences, in 2008, we established a Loggerhead Biological Review Team (BRT) together with FWS to assess the global loggerhead population structure to

determine whether DPSs exist and, if so, the status of each DPS. The BRT evaluated genetic data, tagging and telemetry data, demographic information, oceanographic features, and geographic barriers to determine whether population segments exist. The BRT report was completed in August 2009 (Conant *et al.* 2009). In this report, the BRT identified the following nine DPSs as being discrete from other conspecific population segments and significant to the species: (1) North Pacific Ocean, (2) South Pacific Ocean, (3) North Indian Ocean, (4) Southeast Indo-Pacific Ocean, (5) Southwest Indian Ocean, (6) Northwest Atlantic Ocean, (7) Northeast Atlantic Ocean, (8) Mediterranean Sea, and (9) South Atlantic Ocean.

The BRT concluded that although some DPSs are indicating increasing trends at nesting beaches (Southwest Indian Ocean and South Atlantic Ocean), available information about anthropogenic threats to juveniles and adults in neritic and oceanic environments indicate possible unsustainable additional mortalities. According to an analysis using expert opinion in a matrix model framework, the BRT report stated that all loggerhead DPSs have the potential to decline in the foreseeable future. Based on the threat matrix analysis, the potential for future decline was reported as greatest for the North Indian Ocean, Northwest Atlantic Ocean, Northeast Atlantic Ocean, Mediterranean Sea, and South Atlantic Ocean DPSs (Conant *et al.* 2009). The BRT concluded that the North Pacific Ocean, South Pacific Ocean, North Indian Ocean, Southeast Indo-Pacific Ocean, Northwest Atlantic Ocean, Northeast Atlantic Ocean, and Mediterranean Sea DPSs were at risk of extinction. The BRT concluded that although the Southwest Indian Ocean and South Atlantic Ocean DPSs were likely not currently at immediate risk of extinction, the extinction risk was likely to increase in the foreseeable future.

On March 16, 2010, we published a proposed rule with USFWS (75 FR 12598) to divide the worldwide population of loggerhead sea turtles into nine DPSs, as described in the 2009 Status Review. Two of the DPSs were proposed to be listed as threatened and seven of the DPSs, including the Northwest Atlantic Ocean DPS, were proposed to be listed as endangered. NMFS and the USFWS accepted comments on the proposed rule through September 13, 2010 (75 FR 30769, June 2, 2010). On March 22, 2011 (76 FR 15932), NMFS and USFWS extended the date by which a final determination on the listing action will be made to no later than September 16, 2011. This action was taken to address the interpretation of the existing data on status and trends and its relevance to the assessment of risk of extinction for the Northwest Atlantic Ocean DPS, as well as the magnitude and immediacy of the fisheries bycatch threat and measures to reduce this threat. New information or analyses to help clarify these issues were requested by April 11, 2011.

On September 22, 2011, we issued a final rule with USFWS (76 FR 58868), determining that the loggerhead sea turtle is composed of nine DPSs (as defined in Conant *et al.*, 2009) that constitute species that may be listed as threatened or endangered under the ESA. Five DPSs were listed as endangered (North Pacific Ocean, South Pacific Ocean, North Indian Ocean, Northeast Atlantic Ocean, and Mediterranean Sea), and four DPSs were listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean). Note that the Northwest Atlantic Ocean (NWA) DPS and the Southeast Indo-Pacific Ocean DPS were originally proposed as endangered. The NWA DPS was determined to be threatened based on review of nesting data available after the proposed rule was published, information provided in

public comments on the proposed rule, and further discussions within the agencies. The two primary factors considered were population abundance and population trend. We found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats. This final listing rule became effective on October 24, 2011.

The September 2011 final rule also noted that critical habitat for the two DPSs occurring within the U.S. (NWA DPS and North Pacific DPS) will be designated in a future rulemaking. Information from the public related to the identification of critical habitat, essential physical or biological features for this species, and other relevant impacts of a critical habitat designation was solicited. Currently, no critical habitat is designated for any DPS of loggerhead sea turtles, and therefore, no critical habitat for any DPS occurs in the action area.

Presence of Loggerhead Sea Turtles in the Action Area

The effects of this proposed action are only experienced within the Atlantic Ocean. We have considered the available information on the distribution of the 9 DPSs to determine the origin of any loggerhead sea turtles that may occur in the action area. As noted in Conant *et al.* (2009), the range of the four DPSs occurring in the Atlantic Ocean are as follows: NWA DPS – north of the equator, south of 60° N latitude, and west of 40° W longitude; Northeast Atlantic Ocean (NEA) DPS – north of the equator, south of 60° N latitude, east of 40° W longitude, and west of 5° 36' W longitude; South Atlantic DPS – south of the equator, north of 60° S latitude, west of 20° E longitude, and east of 60° W longitude; Mediterranean DPS – the Mediterranean Sea east of 5° 36' W longitude. These boundaries were determined based on oceanographic features, loggerhead sightings, thermal tolerance, fishery bycatch data, and information on loggerhead distribution from satellite telemetry and flipper tagging studies. While adults are highly structured with no overlap, there may be some degree of overlap by juveniles of the NWA, NEA, and Mediterranean DPSs on oceanic foraging grounds (Laurent *et al.* 1993, 1998; Bolten *et al.* 1998; LaCasella *et al.* 2005; Carreras *et al.* 2006; Monzón-Argüello *et al.* 2006; Revelles *et al.* 2007). Previous literature (Bowen *et al.* 2004) has suggested that there is the potential, albeit small, for some juveniles from the Mediterranean DPS to be present in U.S. Atlantic coastal foraging grounds. These conclusions must be interpreted with caution however, as they may be representing a shared common haplotype and lack of representative sampling at Eastern Atlantic rookeries rather than an actual presence of Mediterranean DPS turtles in US Atlantic coastal waters. A re-analysis of the data by the Atlantic loggerhead Turtle Expert Working Group has found that that it is unlikely that U.S. fishing fleets are interacting with either the Northeast Atlantic loggerhead DPS or the Mediterranean loggerhead DPS (Peter Dutton, NMFS, Marine Turtle Genetics Program, Program Leader, personal communication, September 10, 2011). Given that the action area is a subset of the area fished by US fleets, it is reasonable to assume that based on this new analysis, no individuals from the Mediterranean DPS or Northeast Atlantic DPS would be present in the action area. Sea turtles of the South Atlantic DPS do not inhabit the action area of this consultation (Conant *et al.* 2009). As such, the remainder of this consultation will only focus on the NWA DPS, listed as threatened.

Distribution and Life History

Ehrhart *et al.* (2003) provided a summary of the literature identifying known nesting habitats and foraging areas for loggerheads within the Atlantic Ocean. Detailed information is also provided in the 5-year status review for loggerheads (NMFS and USFWS 2007a), the TEWG report (2009), and the final revised recovery plan for loggerheads in the Northwest Atlantic Ocean (NMFS and USFWS 2008), which is a second revision to the original recovery plan that was approved in 1984 and subsequently revised in 1991.

In the western Atlantic, waters as far north as 41° N to 42° N latitude are used for foraging by juveniles, as well as adults (Shoop 1987; Shoop and Kenney 1992; Ehrhart *et al.* 2003; Mitchell *et al.* 2003). In U.S. Atlantic waters, loggerheads commonly occur throughout the inner continental shelf from Florida to Cape Cod, Massachusetts and in the Gulf of Mexico from Florida to Texas, although their presence varies with the seasons due to changes in water temperature (Shoop and Kenney 1992; Epperly *et al.* 1995a, 1995b; Braun and Epperly 1996; Braun-McNeill *et al.* 2008; Mitchell *et al.* 2003). Loggerheads have been observed in waters with surface temperatures of 7°C to 30°C, but water temperatures $\geq 11^\circ\text{C}$ are most favorable (Shoop and Kenney 1992; Epperly *et al.* 1995b). The presence of loggerhead sea turtles in U.S. Atlantic waters is also influenced by water depth. Aerial surveys of continental shelf waters north of Cape Hatteras, North Carolina indicated that loggerhead sea turtles were most commonly sighted in waters with bottom depths ranging from 22 m to 49 m deep (Shoop and Kenney 1992). However, more recent survey and satellite tracking data support that they occur in waters from the beach to beyond the continental shelf (Mitchell *et al.* 2003; Braun-McNeill and Epperly 2004; Mansfield 2006; Blumenthal *et al.* 2006; Hawkes *et al.* 2006; McClellan and Read 2007; Mansfield *et al.* 2009).

Loggerhead sea turtles occur year round in ocean waters off North Carolina, South Carolina, Georgia, and Florida. In these areas of the South Atlantic Bight, water temperature is influenced by the proximity of the Gulf Stream. As coastal water temperatures warm in the spring, loggerheads begin to migrate to inshore waters of the Southeast United States (*e.g.*, Pamlico and Core Sounds) and also move up the U.S. Atlantic coast (Epperly *et al.* 1995a, 1995b, 1995c; Braun-McNeill and Epperly 2004), occurring in Virginia foraging areas as early as April/May and on the most northern foraging grounds in the Gulf of Maine in June (Shoop and Kenney 1992). The trend is reversed in the fall as water temperatures cool. The large majority leave the Gulf of Maine by mid-September but some turtles may remain in Mid-Atlantic and Northeast areas until late fall. By December, loggerheads have migrated from inshore and more northern coastal waters to waters offshore of North Carolina, particularly off of Cape Hatteras, and waters further south where the influence of the Gulf Stream provides temperatures favorable to sea turtles (Shoop and Kenney 1992; Epperly *et al.* 1995b).

Recent studies have established that the loggerhead's life history is more complex than previously believed. Rather than making discrete developmental shifts from oceanic to neritic environments, research is showing that both adults and (presumed) neritic stage juveniles continue to use the oceanic environment and will move back and forth between the two habitats (Witzell 2002; Blumenthal *et al.* 2006; Hawkes *et al.* 2006; McClellan and Read 2007; Mansfield *et al.* 2009). One of the studies tracked the movements of adult post-nesting females and found that differences in habitat use were related to body size with larger adults staying in

coastal waters and smaller adults traveling to oceanic waters (Hawkes *et al.* 2006). A tracking study of large juveniles found that the habitat preferences of this life stage were also diverse with some remaining in neritic waters and others moving off into oceanic waters (McClellan and Read 2007). However, unlike the Hawkes *et al.* (2006) study, there was no significant difference in the body size of turtles that remained in neritic waters versus oceanic waters (McClellan and Read 2007).

Pelagic and benthic juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988; NMFS and USFWS 2008). Sub-adult and adult loggerheads are primarily coastal dwelling and typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hard bottom habitats (NMFS and USFWS 2008).

As presented below, Table 3 from the 2008 loggerhead recovery plan (Table 4 in this Opinion) highlights the key life history parameters for loggerheads nesting in the United States.

Table 4: Typical values of life history parameters for loggerheads nesting in the U.S.

Life History Parameter	Data
Clutch size	100-126 eggs ¹
Egg incubation duration (varies depending on time of year and latitude)	42-75 days ^{2,3}
Pivotal temperature (incubation temperature that produces an equal number of males and females)	29.0°C ⁵
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70% ^{2,6}
Clutch frequency (number of nests/female/season)	3-5.5 nests ⁷
Interesting interval (number of days between successive nests within a season)	12-15 days ⁸
Juvenile (<87 cm CCL) sex ratio	65-70% female ⁴
Remigration interval (number of years between successive nesting migrations)	2.5-3.7 years ⁹
Nesting season	late April-early September
Hatching season	late June-early November
Age at sexual maturity	32-35 years ¹⁰
Life span	>57 years ¹¹

¹ Dodd 1988.

² Dodd and Mackinnon (1999, 2000, 2001, 2002, 2003, 2004).

³ Blair Witherington, FFWCC, personal communication, 2006 (information based on nests monitored throughout Florida beaches in 2005, n=865).

⁴ National Marine Fisheries Service (2001); Allen Foley, FFWCC, personal communication, 2005.

⁵ Mrosovsky (1988).

⁶ Blair Witherington, FFWCC, personal communication, 2006 (information based on nests monitored throughout Florida beaches in 2005, n=1,680).

⁷ Murphy and Hopkins (1984); Frazer and Richardson (1985); Ehrhart, unpublished data; Hawkes *et al.* 2005; Scott 2006; Tony Tucker, Mote Marine Laboratory, personal communication, 2008.

⁸ Caldwell (1962), Dodd (1988).

⁹ Richardson *et al.* (1978); Bjørndal *et al.* (1983); Ehrhart, unpublished data.

¹⁰ Melissa Snover, NMFS, personal communication, 2005; see Table A1-6.

¹¹ Dahlen *et al.* (2000).

Population Dynamics and Status

By far, the majority of Atlantic nesting occurs on beaches of the southeastern United States (NMFS and USFWS 2007a). For the past decade or so, the scientific literature has recognized five distinct nesting groups, or subpopulations, of loggerhead sea turtles in the Northwest Atlantic, divided geographically as follows: (1) a northern group of nesting females that nest from North Carolina to northeast Florida at about 29° N latitude; (2) a south Florida group of

nesting females that nest from 29° N latitude on the east coast to Sarasota on the west coast; (3) a Florida Panhandle group of nesting females that nest around Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán group of nesting females that nest on beaches of the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas group that nests on beaches of the islands of the Dry Tortugas, near Key West, Florida and on Cal Sal Bank (TEWG 2009). Genetic analyses of mitochondrial DNA, which a sea turtle inherits from its mother, indicate that there are genetic differences between loggerheads that nest at and originate from the beaches used by each of the five identified nesting groups of females (TEWG 2009). However, analyses of microsatellite loci from nuclear DNA, which represents the genetic contribution from both parents, indicates little to no genetic differences between loggerheads originating from nesting beaches of the five Northwest Atlantic nesting groups (Pearce and Bowen 2001; Bowen 2003; Bowen *et al.* 2005; Shamblin 2007). These results suggest that female loggerheads have site fidelity to nesting beaches within a particular area, while males provide an avenue of gene flow between nesting groups by mating with females that originate from different nesting groups (Bowen 2003; Bowen *et al.* 2005). The extent of such gene flow, however, is unclear (Shamblin 2007).

The lack of genetic structure makes it difficult to designate specific boundaries for the nesting subpopulations based on genetic differences alone. Therefore, the Loggerhead Recovery Team recently used a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries, in addition to genetic differences, to reassess the designation of these subpopulations to identify recovery units in the 2008 recovery plan.

In the 2008 recovery plan, the Loggerhead Recovery Team designated five recovery units for the Northwest Atlantic population of loggerhead sea turtles based on the aforementioned nesting groups and inclusive of a few other nesting areas not mentioned above. The first four of these recovery units represent nesting assemblages located in the Southeast United States. The fifth recovery unit is composed of all other nesting assemblages of loggerheads within the Greater Caribbean, outside the United States, but which occur within U.S. waters during some portion of their lives. The five recovery units representing nesting assemblages are: (1) the Northern Recovery Unit (NRU: Florida/Georgia border through southern Virginia), (2) the Peninsular Florida Recovery Unit (PFRU: Florida/Georgia border through Pinellas County, Florida), (3) the Dry Tortugas Recovery Unit (DTRU: islands located west of Key West, Florida), (4) the Northern Gulf of Mexico Recovery Unit (NGMRU: Franklin County, Florida through Texas), and (5) the Greater Caribbean Recovery Unit (GCRU: Mexico through French Guiana, Bahamas, Lesser Antilles, and Greater Antilles).

The Recovery Team evaluated the status and trends of the Northwest Atlantic loggerhead population for each of the five recovery units, using nesting data available as of October 2008 (NMFS and USFWS 2008). The level and consistency of nesting coverage varies among recovery units, with coverage in Florida generally being the most consistent and thorough over time. Since 1989, nest count surveys in Florida have occurred in the form of statewide surveys (a near complete census of entire Florida nesting) and index beach surveys (Witherington *et al.* 2009). Index beaches were established to standardize data collection methods and maintain a constant level of effort on key nesting beaches over time.

Note that NMFS and USFWS (2008), Witherington *et al.* (2009), and TEWG (2009) analyzed the status of the nesting assemblages within the NWA DPS using standardized data collected over periods ranging from 10-23 years. These analyses used different analytical approaches, but found the same finding that there had been a significant, overall nesting decline within the NWA DPS. However, with the addition of nesting data from 2008-2010, the trend line changes showing a very slight negative trend, but the rate of decline is not statistically different from zero (76 FR 58868, September 22, 2011). The nesting data presented in the Recovery Plan (through 2008) is described below, with updated trend information through 2010 for two recovery units.

From the beginning of standardized index surveys in 1989 until 1998, the PFRU, the largest nesting assemblage in the Northwest Atlantic by an order of magnitude, had a significant increase in the number of nests. However, from 1998 through 2008, there was a 41% decrease in annual nest counts from index beaches, which represent an average of 70% of the statewide nesting activity (NMFS and USFWS 2008). From 1989-2008, the PFRU had an overall declining nesting trend of 26% (95% CI: -42% to -5%; NMFS and USFWS 2008). With the addition of nesting data through 2010, the nesting trend for the PFRU does not show a nesting decline statistically different from zero (76 FR 58868, September 22, 2011). The NRU, the second largest nesting assemblage of loggerheads in the United States, has been declining at a rate of 1.3% annually since 1983 (NMFS and USFWS 2008). The NRU dataset included 11 beaches with an uninterrupted time series of coverage of at least 20 years; these beaches represent approximately 27% of NRU nesting (in 2008). Through 2008, there was strong statistical data to suggest the NRU has experienced a long-term decline, but with the inclusion of nesting data through 2010, nesting for the NRU is showing possible signs of stabilizing (76 FR 58868, September 22, 2011). Evaluation of long-term nesting trends for the NGMRU is difficult because of changed and expanded beach coverage. However, the NGMRU has shown a significant declining trend of 4.7% annually since index nesting beach surveys were initiated in 1997 (NMFS and USFWS 2008). No statistical trends in nesting abundance can be determined for the DTRU because of the lack of long-term data. Similarly, statistically valid analyses of long-term nesting trends for the entire GCRU are not available because there are few long-term standardized nesting surveys representative of the region. Additionally, changing survey effort at monitored beaches and scattered and low-level nesting by loggerheads at many locations currently precludes comprehensive analyses (NMFS and USFWS 2008).

Sea turtle census nesting surveys are important in that they provide information on the relative abundance of nesting each year, and the contribution of each nesting group to total nesting of the species. Nest counts can also be used to estimate the number of reproductively mature females nesting annually. The 2008 recovery plan compiled information on mean number of loggerhead nests and the approximated counts of nesting females per year for four of the five identified recovery units (*i.e.*, nesting groups). They are: (1) for the NRU, a mean of 5,215 loggerhead nests per year (from 1989-2008) with approximately 1,272 females nesting per year; (2) for the PFRU, a mean of 64,513 nests per year (from 1989-2007) with approximately 15,735 females nesting per year; (3) for the DTRU, a mean of 246 nests per year (from 1995-2004, excluding 2002) with approximately 60 females nesting per year; and (4) for the NGMRU, a mean of 906 nests per year (from 1995-2007) with approximately 221 females nesting per year. For the

GCRU, the only estimate available for the number of loggerhead nests per year is from Quintana Roo, Yucatán, Mexico, where a range of 903-2,331 nests per year was estimated from 1987-2001 (NMFS and USFWS 2007a). There are no annual nest estimates available for the Yucatán since 2001 or for any other regions in the GCRU, nor are there any estimates of the number of nesting females per year for any nesting assemblage in this recovery unit. Note that the above values for average nesting females per year were based upon 4.1 nests per female per Murphy and Hopkins (1984).

Genetic studies of juvenile and a few adult loggerhead sea turtles collected from Northwest Atlantic foraging areas (beach strandings, a power plant in Florida, and North Carolina fisheries) show that the loggerheads that occupy East Coast U.S. waters originate from these Northwest Atlantic nesting groups; primarily from the nearby nesting beaches of southern Florida, as well as the northern Florida to North Carolina beaches, and finally from the beaches of the Yucatán Peninsula, Mexico (Rankin-Baransky *et al.* 2001; Witzell *et al.* 2002; Bass *et al.* 2004; Bowen *et al.* 2004). The contribution of these three nesting assemblages varies somewhat among the foraging habitats and age classes surveyed along the east coast. The distribution is not random and bears a significant relationship to the proximity and size of adjacent nesting colonies (Bowen *et al.* 2004). Bass *et al.* (2004) attribute the variety in the proportions of sea turtles from loggerhead turtle nesting assemblages documented in different east coast foraging habitats to a complex interplay of currents and the relative size and proximity of nesting beaches.

Unlike nesting surveys, in-water studies of sea turtles typically sample both sexes and multiple age classes. In-water studies have been conducted in some areas of the Northwest Atlantic and provide data by which to assess the relative abundance of loggerhead sea turtles and changes in abundance over time (Maier *et al.* 2004; Morreale *et al.* 2005; Mansfield 2006; Ehrhart *et al.* 2007; Epperly *et al.* 2007). The TEWG (2009) used raw data from six in-water study sites to conduct trend analyses. They identified an increasing trend in the abundance of loggerheads from three of the four sites located in the Southeast United States, one site showed no discernible trend, and the two sites located in the northeast United States showed a decreasing trend in abundance of loggerheads. The 2008 loggerhead recovery plan also includes a full discussion of in-water population studies for which trend data have been reported, and a brief summary will be provided here.

Maier *et al.* (2004) used fishery-independent trawl data to establish a regional index of loggerhead abundance for the southeast coast of the United States (Winyah Bay, South Carolina to St. Augustine, Florida) during the period 2000-2003. A comparison of loggerhead catch data from this study with historical values suggested that in-water populations of loggerhead sea turtles along the southeast U.S. coast appear to be larger, possibly an order of magnitude higher than they were 25 years ago, but the authors caution a direct comparison between the two studies given differences in sampling methodology (Maier *et al.* 2004). A comparison of catch rates for sea turtles in pound net gear fished in the Pamlico-Albemarle Estuarine Complex of North Carolina between the years 1995-1997 and 2001-2003 found a significant increase in catch rates for loggerhead sea turtles for the latter period (Epperly *et al.* 2007). A long-term, on-going study of loggerhead abundance in the Indian River Lagoon System of Florida found a significant increase in the relative abundance of loggerheads over the last 4 years of the study (Ehrhart *et al.*

2007). However, there was no discernible trend in loggerhead abundance during the 24-year time period of the study (1982-2006) (Ehrhart *et al.* 2007). At St. Lucie Power Plant, data collected from 1977-2004 show an increasing trend of loggerheads at the power plant intake structures (FPL and Quantum Resources 2005).

In contrast to these studies, Morreale *et al.* (2005) observed a decline in the percentage and relative numbers of loggerhead sea turtles incidentally captured in pound net gear fished around Long Island, New York during the period 2002-2004 in comparison to the period 1987-1992, with only two loggerheads (of a total 54 turtles) observed captured in pound net gear during the period 2002-2004. This is in contrast to the previous decade's study where numbers of individual loggerheads ranged from 11 to 28 per year (Morreale *et al.* 2005). No additional loggerheads were reported captured in pound net gear in New York through 2007, although two were found cold-stunned on Long Island bay beaches in the fall of 2007 (Memo to the File, L. Lankshear, December 2007). Potential explanations for this decline include major shifts in loggerhead foraging areas and/or increased mortality in pelagic or early benthic stage/age classes (Morreale *et al.* 2005). Using aerial surveys, Mansfield (2006) also found a decline in the densities of loggerhead sea turtles in Chesapeake Bay over the period 2001-2004 compared to aerial survey data collected in the 1980s. Significantly fewer loggerheads ($p < 0.05$) were observed in both the spring (May-June) and the summer (July-August) of 2001-2004 compared to those observed during aerial surveys in the 1980s (Mansfield 2006). A comparison of median densities from the 1980s to the 2000s suggested that there had been a 63.2% reduction in densities during the spring residency period and a 74.9% reduction in densities during the summer residency period (Mansfield 2006). The decline in observed loggerhead populations in Chesapeake Bay may be related to a significant decline in prey, namely horseshoe crabs and blue crabs, with loggerheads redistributing outside of Bay waters (NMFS and USFWS 2008).

As with other turtle species, population estimates for loggerhead sea turtles are difficult to determine, largely given their life history characteristics. However, a recent loggerhead assessment using a demographic matrix model estimated that the loggerhead adult female population in the western North Atlantic ranges from 16,847 to 89,649, with a median size of 30,050 (NMFS SEFSC 2009). The model results for population trajectory suggest that the population is most likely declining, but this result was very sensitive to the choice of the position of the parameters within their range and hypothesized distributions. The pelagic stage survival parameter had the largest effect on the model results. As a result of the large uncertainty in our knowledge of loggerhead life history, at this point predicting the future populations or population trajectories of loggerhead sea turtles with precision is very uncertain. It should also be noted that additional analyses are underway which will incorporate any newly available information.

As part of the Atlantic Marine Assessment Program for Protected Species (AMAPPS), line transect aerial abundance surveys and turtle telemetry studies were conducted along the Atlantic coast in the summer of 2010. AMAPPS is a multi-agency initiative to assess marine mammal, sea turtle, and seabird abundance and distribution in the Atlantic. Aerial surveys were conducted from Cape Canaveral, Florida to the Gulf of St. Lawrence, Canada. Satellite tags on juvenile loggerheads were deployed in two locations – off the coasts of northern Florida to South Carolina (n=30) and off the New Jersey and Delaware coasts (n=14). As presented in NMFS

NEFSC (2011), the 2010 survey found a preliminary total surface abundance estimate within the entire study area of about 60,000 loggerheads (CV=0.13) or 85,000 if a portion of unidentified hard-shelled sea turtles were included (CV=0.10). Surfacing times were generated from the satellite tag data collected during the aerial survey period, resulting in a 7% (5%-11% inter-quartile range) median surface time in the South Atlantic area and a 67% (57%-77% inter-quartile range) median surface time to the north. The calculated preliminary regional abundance estimate is about 588,000 loggerheads along the U.S. Atlantic coast, with an inter-quartile range of 382,000-817,000 (NMFS NEFSC 2011). The estimate increases to approximately 801,000 (inter-quartile range of 521,000-1,111,000) when based on known loggerheads and a portion of unidentified turtle sightings. The density of loggerheads was generally lower in the north than the south; based on number of turtle groups detected, 64% were seen south of Cape Hatteras, North Carolina, 30% in the southern Mid-Atlantic Bight, and 6% in the northern Mid-Atlantic Bight. Although they have been seen farther north in previous studies (*e.g.*, Shoop and Kenney 1992), no loggerheads were observed during the aerial surveys conducted in the summer of 2010 in the more northern zone encompassing Georges Bank, Cape Cod Bay, and the Gulf of Maine. These estimates of loggerhead abundance over the U.S. Atlantic continental shelf are considered very preliminary. A more thorough analysis will be completed pending the results of further studies related to improving estimates of regional and seasonal variation in loggerhead surface time (by increasing the sample size and geographical area of tagging) and other information needed to improve the biases inherent in aerial surveys of sea turtles (*e.g.*, research on depth of detection and species misidentification rate). This survey effort represents the most comprehensive assessment of sea turtle abundance and distribution in many years. Additional aerial surveys and research to improve the abundance estimates are anticipated in 2011-2014, depending on available funds.

Threats

The diversity of a sea turtle's life history leaves them susceptible to many natural and human impacts, including impacts while they are on land, in the neritic environment, and in the oceanic environment. The 5-year status review and 2008 recovery plan provide a summary of natural as well as anthropogenic threats to loggerhead sea turtles (NMFS and USFWS 2007a, 2008). Amongst those of natural origin, hurricanes are known to be destructive to sea turtle nests. Sand accretion, rainfall, and wave action that result from these storms can appreciably reduce hatchling success. Other sources of natural mortality include cold-stunning, biotoxin exposure, and native species predation.

Anthropogenic factors that impact hatchlings and adult females on land, or the success of nesting and hatching include: beach erosion, beach armoring, and nourishment; artificial lighting; beach cleaning; beach pollution; increased human presence; recreational beach equipment; vehicular and pedestrian traffic; coastal development/construction; exotic dune and beach vegetation; removal of native vegetation; and poaching. An increased human presence at some nesting beaches or close to nesting beaches has led to secondary threats such as the introduction of exotic fire ants, feral hogs, dogs, and an increased presence of native species (*e.g.*, raccoons, armadillos, and opossums), which raid nests and feed on turtle eggs (NMFS and USFWS 2007a, 2008). Although sea turtle nesting beaches are protected along large expanses of the Northwest Atlantic coast (in areas like Merritt Island, Archie Carr, and Hobe Sound National Wildlife Refuges),

other areas along these coasts have limited or no protection. Sea turtle nesting and hatching success on unprotected high density East Florida nesting beaches from Indian River to Broward County are affected by all of the above threats.

Loggerheads are affected by a completely different set of anthropogenic threats in the marine environment. These include oil and gas exploration, coastal development, and transportation; marine pollution; underwater explosions; hopper dredging; offshore artificial lighting; power plant entrainment and/or impingement; entanglement in debris; ingestion of marine debris; marina and dock construction and operation; boat collisions; poaching; and fishery interactions.

A 1990 National Research Council (NRC) report concluded that for juveniles, subadults, and breeding adults in coastal waters, the most important source of human caused mortality in U.S. Atlantic waters was fishery interactions. The sizes and reproductive values of sea turtles taken by fisheries vary significantly, depending on the location and season of the fishery, and size-selectivity resulting from gear characteristics. Therefore, it is possible for fisheries that interact with fewer, more reproductively valuable turtles to have a greater detrimental effect on the population than one that takes greater numbers of less reproductively valuable turtles (Wallace *et al.* 2008). The Loggerhead Biological Review Team determined that the greatest threats to the NWA DPS of loggerheads result from cumulative fishery bycatch in neritic and oceanic habitats (Conant *et al.* 2009). Attaining a more thorough understanding of the characteristics, as well as the quantity of sea turtle bycatch across all fisheries is of great importance.

Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). The Southeast/Gulf of Mexico shrimp trawl fishery was responsible for the vast majority of U.S. interactions (up to 98%) and mortalities (more than 80%). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

Of the many fisheries known to adversely affect loggerheads, the U.S. South Atlantic and Gulf of Mexico shrimp fisheries were considered to pose the greatest threat of mortality to neritic juvenile and adult age classes of loggerheads (NRC 1990, Finkbeiner *et al.* 2011). Significant changes to the South Atlantic and Gulf of Mexico shrimp fisheries have occurred since 1990, and the effects of these shrimp fisheries on ESA-listed species, including loggerhead sea turtles, have been assessed several times through section 7 consultation. There is also a lengthy regulatory history with regard to the use of Turtle Excluder Devices (TEDs) in the U.S. South Atlantic and Gulf of Mexico shrimp fisheries (Epperly and Teas 2002; NMFS 2002a; Lewison *et al.* 2003). The current section 7 consultation on the U.S. South Atlantic and Gulf of Mexico shrimp fisheries was completed in 2002 and estimated the total annual level of take for loggerhead sea turtles to be 163,160 interactions (the total number of turtles that enter a shrimp trawl, which

may then escape through the TED or fail to escape and be captured) with 3,948 of those takes being lethal (NMFS 2002a).

In addition to improvements in TED designs and TED enforcement, interactions between loggerheads and the shrimp fishery have also been declining because of reductions in fishing effort unrelated to fisheries management actions. The 2002 Opinion take estimates are based in part on fishery effort levels. In recent years, low shrimp prices, rising fuel costs, competition with imported products, and the impacts of recent hurricanes in the Gulf of Mexico have all impacted the shrimp fleets; in some cases reducing fishing effort by as much as 50% for offshore waters of the Gulf of Mexico (GMFMC 2007). As a result, loggerhead interactions and mortalities in the Gulf of Mexico have been substantially less than projected in the 2002 Opinion. Currently, the estimated annual number of interactions between loggerheads and shrimp trawls in the Gulf of Mexico shrimp fishery is 23,336, with 647 (2.8%) of those interactions resulting in mortality (Memo from Dr. B. Ponwith, Southeast Fisheries Science Center to Dr. R. Crabtree, Southeast Region, PRD, December 2008). Section 7 consultation on the Shrimp FMP has recently been reinitiated and a new Biological Opinion is forthcoming.

Loggerhead sea turtles are also known to interact with non-shrimp trawl, gillnet, longline, dredge, pound net, pot/trap, and hook and line fisheries. The NRC (1990) report stated that other U.S. Atlantic fisheries collectively accounted for 500 to 5,000 loggerhead deaths each year, but recognized that there was considerable uncertainty in the estimate. The reduction of sea turtle captures in fishing operations is identified in recovery plans and 5-year status reviews as a priority for the recovery of all sea turtle species. In the threats analysis of the loggerhead recovery plan, trawl bycatch is identified as the greatest source of mortality. While loggerhead bycatch in U.S. Mid-Atlantic bottom otter trawl gear was previously estimated for the period 1996-2004 (Murray 2006, 2008), a recent bycatch analysis estimated the number of loggerhead sea turtle interactions with U.S. Mid-Atlantic bottom trawl gear from 2005-2008 (Warden 2011a). Northeast Fisheries Observer Program data from 1994-2008 were used to develop a model of interaction rates and those predicted rates were applied to 2005-2008 commercial fishing data to estimate the number of interactions for the trawl fleet. The number of predicted average annual loggerhead interactions for 2005-2008 was 292 (CV=0.13, 95% CI=221-369), with an additional 61 loggerheads (CV=0.17, 95% CI=41-83) interacting with trawls but being released through a TED. Of the 292 average annual observable loggerhead interactions, approximately 44 of those were adult equivalents. Warden (2011b) found that latitude, depth and SST were associated with the interaction rate, with the rates being highest south of 37°N latitude in waters < 50 m deep and SST > 15°C. This estimate is a decrease from the average annual loggerhead bycatch in bottom otter trawls during 1996-2004, estimated to be 616 sea turtles (CV=0.23, 95% CI over the 9-year period: 367-890) (Murray 2006, 2008).

There have been several published estimates of the number of loggerheads taken annually as a result of the dredge fishery for Atlantic sea scallops, ranging from a low of zero in 2005 (Murray 2007) to a high of 749 in 2003 (Murray 2004). Murray (2011) recently re-evaluated loggerhead sea turtle interactions in scallop dredge gear from 2001-2008. In that paper, the average number of annual observable interactions of hard-shelled sea turtles in the Mid-Atlantic scallop dredge fishery prior to the implementation of chain mats (January 1, 2001 through September 25, 2006)

was estimated to be 288 turtles (CV = 0.14, 95% CI: 209-363) [equivalent to 49 adults], 218 of which were loggerheads [equivalent to 37 adults]. After the implementation of chain mats, the average annual number of observable interactions was estimated to be 20 hard-shelled sea turtles (CV = 0.48, 95% CI: 3-42), 19 of which were loggerheads. If the rate of observable interactions from dredges without chain mats had been applied to trips with chain mats, the estimated number of observable and inferred interactions of hard-shelled sea turtles after chain mats were implemented would have been 125 turtles per year (CV = 0.15, 95% CI: 88-163) [equivalent to 22 adults], 95 of which were loggerheads [equivalent to 16 adults]. Interaction rates of hard-shelled turtles were correlated with sea surface temperature, depth, and use of a chain mat. Results from this recent analysis suggest that chain mats and fishing effort reductions have contributed to the decline in estimated loggerhead sea turtle interactions with scallop dredge gear after 2006 (Murray 2011).

An estimate of the number of loggerheads taken annually in U.S. Mid-Atlantic gillnet fisheries has also recently been published (Murray 2009a, b). From 1995-2006, the annual bycatch of loggerheads in U.S. Mid-Atlantic gillnet gear was estimated to average 350 turtles (CV=0.20, 95% CI over the 12-year period: 234 to 504). Bycatch rates were correlated with latitude, sea surface temperature, and mesh size. The highest predicted bycatch rates occurred in warm waters of the southern Mid-Atlantic in large-mesh gillnets (Murray 2009a).

The U.S. tuna and swordfish longline fisheries that are managed under the Highly Migratory Species (HMS) FMP are estimated to capture 1,905 loggerheads (no more than 339 mortalities) for each 3-year period starting in 2007 (NMFS 2004a). NMFS has mandated gear changes for the HMS fishery to reduce sea turtle bycatch and the likelihood of death from those incidental takes that would still occur (Garrison and Stokes 2010). In 2010, there were 40 observed interactions between loggerhead sea turtles and longline gear used in the HMS fishery (Garrison and Stokes 2011a, 2011b). All of the loggerheads were released alive, with the vast majority released with all gear removed. While 2010 total estimates are not yet available, in 2009, 242.9 (95% CI: 167.9-351.2) loggerhead sea turtles are estimated to have been taken in the longline fisheries managed under the HMS FMP based on the observed takes (Garrison and Stokes 2010). The 2009 estimate is considerably lower than those in 2006 and 2007 and is consistent with historical averages since 2001 (Garrison and Stokes 2010). This fishery represents just one of several longline fisheries operating in the Atlantic Ocean. Lewison *et al.* (2004) estimated that 150,000-200,000 loggerheads were taken in all Atlantic longline fisheries in 2000 (including the U.S. Atlantic tuna and swordfish longline fisheries as well as others).

Documented takes also occur in other fishery gear types and by non-fishery mortality sources (*e.g.*, hopper dredges, power plants, vessel collisions), but quantitative estimates are unavailable. Past and future impacts of global climate change are considered in Section 6.0 below.

Summary of Status for Loggerhead Sea Turtles

Loggerheads are a long-lived species and reach sexual maturity relatively late at around 32-35 years in the Northwest Atlantic (NMFS and USFWS 2008). The species continues to be affected by many factors occurring on nesting beaches and in the water. These include poaching, habitat loss, and nesting predation that affects eggs, hatchlings, and nesting females on land, as well as

fishery interactions, vessel interactions, marine pollution, and non-fishery (e.g., dredging) operations affecting all sexes and age classes in the water (NRC 1990; NMFS and USFWS 2007a, 2008). As a result, loggerheads still face many of the original threats that were the cause of their listing under the ESA.

As mentioned previously, a final revised recovery plan for loggerhead sea turtles in the Northwest Atlantic was recently published by NMFS and FWS in December 2008. The revised recovery plan is significant in that it identifies five unique recovery units, which comprise the population of loggerheads in the Northwest Atlantic, and describes specific recovery criteria for each recovery unit. The recovery plan noted a decline in annual nest counts for three of the five recovery units for loggerheads in the Northwest Atlantic, including the PFRU, which is the largest (in terms of number of nests laid) in the Atlantic Ocean. The nesting trends for the other two recovery units could not be determined due to an absence of long term data.

NMFS convened a new Loggerhead Turtle Expert Working Group (TEWG) to review all available information on Atlantic loggerheads in order to evaluate the status of this species in the Atlantic. A final report from the Loggerhead TEWG was published in July 2009. In this report, the TEWG indicated that it could not determine whether the decreasing annual numbers of nests among the Northwest Atlantic loggerhead subpopulations were due to stochastic processes resulting in fewer nests, a decreasing average reproductive output of adult females, decreasing numbers of adult females, or a combination of these factors. Many factors are responsible for past or present loggerhead mortality that could impact current nest numbers; however, no single mortality factor stands out as a likely primary factor. It is likely that several factors compound to create the current decline, including incidental capture (in fisheries, power plant intakes, and dredging operations), lower adult female survival rates, increases in the proportion of first-time nesters, continued directed harvest, and increases in mortality due to disease. Regardless, the TEWG stated that “it is clear that the current levels of hatchling output will result in depressed recruitment to subsequent life stages over the coming decades” (TEWG 2009). However, the report does not provide information on the rate or amount of expected decrease in recruitment but goes on to state that the ability to assess the current status of loggerhead subpopulations is limited due to a lack of fundamental life history information and specific census and mortality data.

While several documents reported the decline in nesting numbers in the NWA DPS (NMFS and USFWS 2008, TEWG 2009), when nest counts through 2010 are analyzed, the nesting trends from 1989-2010 are not significantly different than zero for all recovery units within the NWA DPS for which there are enough data to analyze (76 FR 58868, September 22, 2011). The SEFSC (2009) estimated the number of adult females in the NWA DPS at 30,000, and if a 1:1 adult sex ratio is assumed, the result is 60,000 adults in this DPS. Based on the reviews of nesting data, as well as information on population abundance and trends, NMFS and USFWS determined in the September 2011 listing rule that the NWA DPS should be listed as threatened. They found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats.

4.3 Status of Kemp's Ridley Sea Turtles

Distribution and Life History

The Kemp's ridley is one of the least abundant of the world's sea turtle species. In contrast to loggerhead, leatherback, and green sea turtles, which are found in multiple oceans of the world, Kemp's ridleys typically occur only in the Gulf of Mexico and the northwestern Atlantic Ocean (NMFS *et al.* 2011).

Kemp's ridleys mature at 10-17 years (Caillouet *et al.* 1995; Schmid and Witzell 1997; Snover *et al.* 2007; NMFS and USFWS 2007c). Nesting occurs from April through July each year with hatchlings emerging after 45-58 days (NMFS *et al.* 2011). Females lay an average of 2.5 clutches within a season (TEWG 1998, 2000) and the mean remigration interval for adult females is 2 years (Marquez *et al.* 1982; TEWG 1998, 2000).

Once they leave the nesting beach, hatchlings presumably enter the Gulf of Mexico where they feed on available *Sargassum* and associated infauna or other epipelagic species (NMFS *et al.* 2011). The presence of juvenile turtles along both the U.S. Atlantic and Gulf of Mexico coasts, where they are recruited to the coastal benthic environment, indicates that post-hatchlings are distributed in both the Gulf of Mexico and Atlantic Ocean (TEWG 2000).

The location and size classes of dead turtles recovered by the STSSN suggests that benthic immature developmental areas occur along the U.S. coast and that these areas may change given resource quality and quantity (TEWG 2000). Developmental habitats are defined by several characteristics, including coastal areas sheltered from high winds and waves such as embayments and estuaries, and nearshore temperate waters shallower than 50 m (NMFS and USFWS 2007c). The suitability of these habitats depends on resource availability, with optimal environments providing rich sources of crabs and other invertebrates. Kemp's ridleys consume a variety of crab species, including *Callinectes*, *Ovalipes*, *Libinia*, and *Cancer* species. Mollusks, shrimp, and fish are consumed less frequently (Bjorndal 1997). A wide variety of substrates have been documented to provide good foraging habitat, including seagrass beds, oyster reefs, sandy and mud bottoms, and rock outcroppings (NMFS and USFWS 2007c).

Foraging areas documented along the U.S. Atlantic coast include Charleston Harbor, Pamlico Sound (Epperly *et al.* 1995c), Chesapeake Bay (Musick and Limpus 1997), Delaware Bay (Stetzar 2002), and Long Island Sound (Morreale and Standora 1993; Morreale *et al.* 2005). For instance, in the Chesapeake Bay, Kemp's ridleys frequently forage in submerged aquatic grass beds for crabs (Musick and Limpus 1997). Upon leaving Chesapeake Bay in autumn, juvenile Kemp's ridleys migrate down the coast, passing Cape Hatteras in December and January (Musick and Limpus 1997). These larger juveniles are joined by juveniles of the same size from North Carolina sounds and smaller juveniles from New York and New England to form one of the densest concentrations of Kemp's ridleys outside of the Gulf of Mexico (Epperly *et al.* 1995a, 1995b; Musick and Limpus 1997).

Adult Kemp's ridleys are found in the coastal regions of the Gulf of Mexico and southeastern United States, but are typically rare in the northeastern U.S. waters of the Atlantic (TEWG

2000). Adults are primarily found in nearshore waters of 37 m or less that are rich in crabs and have a sandy or muddy bottom (NMFS and USFWS 2007c).

Population Dynamics and Status

The majority of Kemp's ridleys nest along a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; NMFS and USFWS 2007c; NMFS *et al.* 2011). There is a limited amount of scattered nesting to the north and south of the primary nesting beach (NMFS and USFWS 2007c). Nesting often occurs in synchronized emergences termed *arribadas*. The number of recorded nests reached an estimated low of 702 nests in 1985, corresponding to fewer than 300 adult females nesting in that season (TEWG 2000; NMFS and USFWS 2007c; NMFS *et al.* 2011). Conservation efforts by Mexican and U.S. agencies have aided this species by eliminating egg harvest, protecting eggs and hatchlings, and reducing at-sea mortality through fishing regulations (TEWG 2000). Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 14-16% per year (Heppell *et al.* 2005), allowing cautious optimism that the population is on its way to recovery. An estimated 5,500 females nested in the State of Tamaulipas over a 3-day period in May 2007 and over 4,000 of those nested at Rancho Nuevo (NMFS and USFWS 2007c). In 2008, 17,882 nests were documented on Mexican nesting beaches (NMFS 2011). There is limited nesting in the United States, most of which is located in South Texas. While six nests were documented in 1996, a record 195 nests were found in 2008 (NMFS 2011).

Threats

Kemp's ridleys face many of the same natural threats as loggerheads, including destruction of nesting habitat from storm events, predators, and oceanographic-related events such as cold-stunning. Although cold-stunning can occur throughout the range of the species, it may be a greater risk for sea turtles that utilize the more northern habitats of Cape Cod Bay and Long Island Sound. In the last five years (2006-2010), the number of cold-stunned turtles on Cape Cod beaches averaged 115 Kemp's ridleys, 7 loggerheads, and 7 greens (NMFS unpublished data). The numbers ranged from a low in 2007 of 27 Kemp's ridleys, 5 loggerheads, and 5 greens to a high in 2010 of 213 Kemp's ridleys, 4 loggerheads, and 14 greens. Annual cold stun events vary in magnitude; the extent of episodic major cold stun events may be associated with numbers of turtles utilizing Northeast U.S. waters in a given year, oceanographic conditions, and/or the occurrence of storm events in the late fall. Although many cold-stunned turtles can survive if they are found early enough, these events represent a significant source of natural mortality for Kemp's ridleys.

Like other sea turtle species, the severe decline in the Kemp's ridley population appears to have been heavily influenced by a combination of exploitation of eggs and impacts from fishery interactions. From the 1940s through the early 1960s, nests from Ranch Nuevo were heavily exploited, but beach protection in 1967 helped to curtail this activity (NMFS *et al.* 2011). Following World War II, there was a substantial increase in the number of trawl vessels, particularly shrimp trawlers, in the Gulf of Mexico where adult Kemp's ridley sea turtles occur. Information from fisheries observers helped to demonstrate the high number of turtles taken in these shrimp trawls (USFWS and NMFS 1992). Subsequently, NMFS has worked with the industry to reduce sea turtle takes in shrimp trawls and other trawl fisheries, including the

development and use of turtle excluder devices (TEDs). As described above, there is lengthy regulatory history with regard to the use of TEDs in the U.S. South Atlantic and Gulf of Mexico shrimp fisheries (NMFS 2002a; Epperly 2003; Lewison *et al.* 2003). The 2002 Biological Opinion on shrimp trawling in the southeastern United States concluded that 155,503 Kemp's ridley sea turtles would be taken annually in the fishery with 4,208 of the takes resulting in mortality (NMFS 2002a).

Although modifications to shrimp trawls have helped to reduce mortality of Kemp's ridleys, a recent assessment found that the Southeast/Gulf of Mexico shrimp trawl fishery remained responsible for the vast majority of U.S. fishery interactions (up to 98%) and mortalities (more than 80%). Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

This species is also affected by other sources of anthropogenic impact (fishery and non-fishery related), similar to those discussed above. Three Kemp's ridley captures in Mid-Atlantic trawl fisheries were documented by NMFS observers between 1994 and 2008 (Warden and Bisack 2010), and eight Kemp's ridleys were documented by NMFS observers in mid-Atlantic sink gillnet fisheries between 1995 and 2006 (Murray 2009a). Additionally, in the spring of 2000, a total of five Kemp's ridley carcasses were recovered from the same North Carolina beaches where 275 loggerhead carcasses were found. The cause of death for most of the turtles recovered was unknown, but the mass mortality event was suspected by NMFS to have been from a large-mesh gillnet fishery for monkfish and dogfish operating offshore in the preceding weeks (67 FR 71895, December 3, 2002). The five Kemp's ridley carcasses that were found are likely to have been only a minimum count of the number of Kemp's ridleys that were killed or seriously injured as a result of the fishery interaction, since it is unlikely that all of the carcasses washed ashore. The NMFS Northeast Fisheries Science Center also documented 14 Kemp's ridleys entangled in or impinged on Virginia pound net leaders from 2002-2005. Note that bycatch estimates for Kemp's ridleys in various fishing gear types (e.g., trawl, gillnet, dredge) are not available at this time, largely due to the low number of observed interactions precluding a robust estimate. Kemp's ridley interactions in non-fisheries have also been observed; for example, the Oyster Creek Nuclear Generating Station in Barnegat Bay, New Jersey, recorded a total of 27 Kemp's ridleys (15 of which were found alive) impinged or captured on their intake screens from 1992-2006 (NMFS 2006).

Summary of Status for Kemp's Ridley Sea Turtles

The majority of Kemp's ridleys nest along a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; NMFS and USFWS 2007c; NMFS *et al.* 2011). The number of nesting females in the Kemp's ridley population declined dramatically from the late 1940s through the mid-1980s, with an estimated 40,000 nesting females in a single *arribada* in 1947 and fewer than 300 nesting females in the entire 1985 nesting season (TEWG 2000; NMFS *et al.* 2011). However, the total annual number of nests at Rancho Nuevo gradually began to increase in the 1990s (NMFS and USFWS 2007c). Based on the number of nests laid in 2006 and the remigration interval for Kemp's ridley sea turtles (1.8-2 years), there were an estimated 7,000-8,000 adult female Kemp's ridley sea turtles in 2006 (NMFS and USFWS 2007c). The number of adult males in the population is unknown, but sex ratios of hatchlings and immature Kemp's ridleys suggest that the population is female-biased, suggesting that the number of adult males is less than the number of adult females (NMFS and USFWS 2007c). While there is cautious optimism for recovery, events such as the Deepwater Horizon oil release, and stranding events associated increased skimmer trawl use and poor TED compliance in the northern Gulf of Mexico may dampen recent population growth.

As with the other sea turtle species, fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches, while other activities like dredging, pollution, and habitat destruction account for an unknown level of other mortality. Based on their 5-year status review of the species, together with USFWS (2007c), we determined that Kemp's ridley sea turtles should not be reclassified as threatened under the ESA. A revised bi-national recovery plan was published for public comment in 2010, and in September 2011, NMFS, USFWS, and the Services and the Secretary of Environment and Natural Resources, Mexico (SEMARNAT) released the second revision to the Kemp's ridley recovery plan.

4.4 Status of Green Sea Turtles

Green sea turtles are distributed circumglobally, and can be found in the Pacific, Indian, and Atlantic Oceans as well as the Mediterranean Sea (NMFS and USFWS 1991, 2007d; Seminoff 2004). In 1978, the Atlantic population of the green sea turtle was listed as threatened under the ESA, except for the breeding populations in Florida and on the Pacific coast of Mexico, which were listed as endangered. As it is difficult to differentiate between breeding populations away from the nesting beaches, all green sea turtles in the water are considered endangered. On March 23, 2015, however, we published a proposed rule with USFWS to reclassify the status of green turtles by identifying 11 distinct population segments (DPSs) as either endangered or threatened. The DPS found in U.S. Atlantic waters, the North Atlantic DPS, is proposed as threatened.

Pacific Ocean

Green sea turtles occur in the western, central, and eastern Pacific. Foraging areas are also found throughout the Pacific and along the southwestern U.S. coast (NMFS and USFWS 1998b). In the western Pacific, major nesting rookeries at four sites including Heron Island (Australia), Raine Island (Australia), Guam, and Japan were evaluated and determined to be increasing in abundance, with the exception of Guam which appears stable (NMFS and USFWS 2007d). In the central Pacific, nesting occurs on French Frigate Shoals, Hawaii, which has also been reported as increasing with a mean of 400 nesting females annually from 2002-2006 (NMFS and USFWS

2007d). The main nesting sites for the green sea turtle in the eastern Pacific are located in Michoacan, Mexico and in the Galapagos Islands, Ecuador (NMFS and USFWS 2007d). The number of nesting females per year exceeds 1,000 females at each site (NMFS and USFWS 2007d). However, historically, greater than 20,000 females per year are believed to have nested in Michoacan alone (Cliffon *et al.* 1982; NMFS and USFWS 2007d). The Pacific Mexico green turtle nesting population (also called the black turtle) is considered endangered.

Historically, green sea turtles were used in many areas of the Pacific for food. They were also commercially exploited, which, coupled with habitat degradation, led to their decline in the Pacific (NMFS and USFWS 1998b). Green sea turtles in the Pacific continue to be affected by poaching, habitat loss or degradation, fishing gear interactions, and fibropapillomatosis, which is a viral disease that causes tumors in affected turtles (NMFS and USFWS 1998b; NMFS 2004b).

Indian Ocean

There are numerous nesting sites for green sea turtles in the Indian Ocean. One of the largest nesting sites for green sea turtles worldwide occurs on the beaches of Oman where an estimated 20,000 green sea turtles nest annually (Hirth 1997; Ferreira *et al.* 2003). Based on a review of the 32 Index Sites used to monitor green sea turtle nesting worldwide, Seminoff (2004) concluded that declines in green sea turtle nesting were evident for many of the Indian Ocean Index Sites. While several of these had not demonstrated further declines in the more recent past, only the Comoros Island Index Site in the western Indian Ocean showed evidence of increased nesting (Seminoff 2004).

Mediterranean Sea

There are four nesting concentrations of green sea turtles in the Mediterranean from which data are available – Turkey, Cyprus, Israel, and Syria. Currently, approximately 300-400 females nest each year, about two-thirds of which nest in Turkey and one-third in Cyprus. Although green sea turtles are depleted from historic levels in the Mediterranean Sea (Kasperek *et al.* 2001), nesting data gathered since the early 1990s in Turkey, Cyprus, and Israel show no apparent trend in any direction. However, a declining trend is apparent along the coast of Palestine/Israel, where 300-350 nests were deposited each year in the 1950s (Sella 1982) compared to a mean of 6 nests per year from 1993-2004 (Kuller 1999; Y. Levy, Israeli Sea Turtle Rescue Center, unpublished data). A recent discovery of green sea turtle nesting in Syria adds roughly 100 nests per year to green sea turtle nesting activity in the Mediterranean (Rees *et al.* 2005). That such a major nesting concentration could have gone unnoticed until recently (the Syria coast was surveyed in 1991, but nesting activity was attributed to loggerheads) bodes well for the ongoing speculation that the unsurveyed coast of Libya may also host substantial nesting.

Atlantic Ocean

Distribution and Life History

As has occurred in other oceans of its range, green sea turtles were once the target of directed fisheries in the United States and throughout the Caribbean. In 1890, over one million pounds of green sea turtles were taken in a directed fishery in the Gulf of Mexico (Doughty 1984). However, declines in the turtle fishery throughout the Gulf of Mexico were evident by 1902 (Doughty 1984).

In the western Atlantic, large juvenile and adult green sea turtles are largely herbivorous, occurring in habitats containing benthic algae and seagrasses from Massachusetts to Argentina, including the Gulf of Mexico and Caribbean (Wynne and Schwartz 1999). Green sea turtles occur seasonally in Mid-Atlantic and Northeast waters such as Chesapeake Bay and Long Island Sound (Musick and Limpus 1997; Morreale and Standora 1998; Morreale *et al.* 2005), which serve as foraging and developmental habitats.

Some of the principal feeding areas in the western Atlantic Ocean include the upper west coast of Florida, the Florida Keys, and the northwestern coast of the Yucatán Peninsula. Additional important foraging areas in the western Atlantic include the Mosquito and Indian River Lagoon systems and nearshore wormrock reefs between Sebastian and Ft. Pierce Inlets in Florida, Florida Bay, the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean coast of Panama, and scattered areas along Colombia and Brazil (Hirth 1971). The waters surrounding the island of Culebra, Puerto Rico, and its outlying keys are designated critical habitat for the green sea turtle.

Age at maturity for green sea turtles is estimated to be 20-50 years (Balazs 1982; Frazer and Ehrhart 1985; Seminoff 2004). As is the case with the other sea turtle species described above, adult females may nest multiple times in a season (average 3 nests/season with approximately 100 eggs/nest) and typically do not nest in successive years (NMFS and USFWS 1991; Hirth 1997).

Population Dynamics and Status

Like other sea turtle species, nest count information for green sea turtles provides information on the relative abundance of nesting, and the contribution of each nesting group to total nesting of the species. Nest counts can also be used to estimate the number of reproductively mature females nesting annually. The 5-year status review for the species identified eight geographic areas considered to be primary sites for threatened green sea turtle nesting in the Atlantic/Caribbean, and reviewed the trend in nest count data for each (NMFS and USFWS 2007d). These include: (1) Yucatán Peninsula, Mexico, (2) Tortuguero, Costa Rica, (3) Aves Island, Venezuela, (4) Galibi Reserve, Suriname, (5) Isla Trindade, Brazil, (6) Ascension Island, United Kingdom, (7) Bioko Island, Equatorial Guinea, and (8) Bijagos Archipelago, Guinea-Bissau (NMFS and USFWS 2007d). Nesting at all of these sites is considered to be stable or increasing with the exception of Bioko Island, which may be declining. However, the lack of sufficient data precludes a meaningful trend assessment for this site (NMFS and USFWS 2007d).

Seminoff (2004) reviewed green sea turtle nesting data for eight sites in the western, eastern, and central Atlantic, including all of the above threatened nesting sites with the exception that nesting in Florida was reviewed in place of Isla Trindade, Brazil. He concluded that all sites in the central and western Atlantic showed increased nesting with the exception of nesting at Aves Island, Venezuela, while both sites in the eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic Ocean. However, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007d).

By far, the most important nesting concentration for green sea turtles in the western Atlantic is in Tortuguero, Costa Rica (NMFS and USFWS 2007d). Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggest nesting by 17,402-37,290 females per year (NMFS and USFWS 2007d). The number of females nesting per year on beaches in the Yucatán, at Aves Island, Galibi Reserve, and Isla Trindade number in the hundreds to low thousands, depending on the site (NMFS and USFWS 2007d).

The status of the endangered Florida breeding population was also evaluated in the 5-year review (NMFS and USFWS 2007d). The pattern of green sea turtle nesting shows biennial peaks in abundance, with a generally positive trend since establishment of the Florida index beach surveys in 1989. This trend is perhaps due to increased protective legislation throughout the Caribbean (Meylan *et al.* 1995), as well as protections in Florida and throughout the United States (NMFS and USFWS 2007d).

The statewide Florida surveys (2000-2006) have shown that a mean of approximately 5,600 nests are laid annually in Florida, with a low of 581 in 2001 to a high of 9,644 in 2005 (NMFS and USFWS 2007d). Most nesting occurs along the east coast of Florida, but occasional nesting has been documented along the Gulf coast of Florida, at Southwest Florida beaches, as well as the beaches in the Florida Panhandle (Meylan *et al.* 1995). More recently, green sea turtle nesting occurred on Bald Head Island, North Carolina (just east of the mouth of the Cape Fear River), Onslow Island, and Cape Hatteras National Seashore. One green sea turtle nested on a beach in Delaware in 2011, although its occurrence was considered very rare.

Threats

Green sea turtles face many of the same natural threats as loggerhead and Kemp's ridley sea turtles. In addition, green sea turtles appear to be particularly susceptible to fibropapillomatosis, an epizootic disease producing lobe-shaped tumors on the soft portion of a turtle's body. Juveniles appear to be most affected in that they have the highest incidence of disease and the most extensive lesions, whereas lesions in nesting adults are rare. Also, green sea turtles frequenting nearshore waters, areas adjacent to large human populations, and areas with low water turnover, such as lagoons, have a higher incidence of the disease than individuals in deeper, more remote waters. The occurrence of fibropapilloma tumors may result in impaired foraging, breathing, or swimming ability, leading potentially to death (George 1997).

As with the other sea turtle species, incidental fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches. Witherington *et al.* (2009) observes that because green sea turtles spend a shorter time in oceanic waters and as older juveniles occur on shallow seagrass pastures (where benthic trawling is unlikely), they avoid high mortalities in pelagic longline and benthic trawl fisheries. Although the relatively low number of observed green sea turtle captures makes it difficult to estimate bycatch rates and annual take levels, green sea turtles have been observed captured in the pelagic driftnet, pelagic longline, southeast shrimp trawl, and mid-Atlantic trawl and gillnet fisheries. Murray (2009a) also lists five observed captures of green turtle in Mid-Atlantic sink gillnet gear between 1995 and 2006.

Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). The Southeast/Gulf of Mexico shrimp trawl fishery was responsible for the vast majority of U.S. interactions (up to 98%) and mortalities (more than 80%). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

Other activities like channel dredging, marine debris, pollution, vessel strikes, power plant impingement, and habitat destruction account for an unquantifiable level of other mortality. Stranding reports indicate that between 200-400 green sea turtles strand annually along the eastern U.S. coast from a variety of causes most of which are unknown (STSSN database).

Summary of Status of Green Sea Turtles

A review of 32 Index Sites⁴ distributed globally revealed a 48-67% decline in the number of mature females nesting annually over the last three generations⁵ (Seminoff 2004). We conducted an evaluation of green sea turtle nesting sites as part of the 5-year status review of the species (NMFS and USFWS 2007d). Of the 23 threatened nesting groups assessed in that report for which nesting abundance trends could be determined, ten were considered to be increasing, nine were considered stable, and four were considered to be decreasing (NMFS and USFWS 2007d). Nesting groups were considered to be doing relatively well (the number of sites with increasing nesting were greater than the number of sites with decreasing nesting) in the Pacific, western Atlantic, and central Atlantic (NMFS and USFWS 2007d). However, nesting populations were determined to be doing relatively poorly in Southeast Asia, eastern Indian Ocean, and perhaps the Mediterranean. Overall, based on mean annual reproductive effort, the report estimated that 108,761 to 150,521 females nest each year among the 46 threatened and endangered nesting sites included in the evaluation (NMFS and USFWS 2007d). However, given the late age to maturity for green sea turtles, caution is urged regarding the status for any of the nesting groups since no area has a dataset spanning a full green sea turtle generation (NMFS and USFWS 2007d).

Seminoff (2004) and NMFS and USFWS (2007d) made comparable conclusions with regard to nesting for four nesting sites in the western Atlantic that indicate sea turtle abundance is increasing in the Atlantic Ocean. Each also concluded that nesting at Tortuguero, Costa Rica represented the most important nesting area for green sea turtles in the western Atlantic and that nesting had increased markedly since the 1970s (Seminoff 2004; NMFS and USFWS 2007d).

⁴ The 32 Index Sites include all of the major known nesting areas as well as many of the lesser nesting areas for which quantitative data are available.

⁵ Generation times ranged from 35.5 years to 49.5 years for the assessment depending on the Index Beach site

However, the 5-year review also noted that the Tortuguero nesting stock continued to be affected by ongoing directed take at their primary foraging area in Nicaragua (NMFS and USFWS 2007d). The endangered breeding population in Florida appears to be increasing based upon index nesting data from 1989-2010 (NMFS 2011).

As with the other sea turtle species, fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches, while other activities like hopper dredging, pollution, and habitat destruction account for an unknown level of other mortality. Based on the 5-year status review of the species, we determined with USFWS (2007d) that the listing classification for green sea turtles should not be changed. However, we also determined that an analysis and review of the species should be conducted in the future to determine whether DPSs should be identified (NMFS and USFWS 2007d).

4.5 Status of Leatherback Sea Turtles

Leatherback sea turtles are widely distributed throughout the oceans of the world, including the Atlantic, Pacific, and Indian Oceans, and the Mediterranean Sea (Ernst and Barbour 1972). Leatherbacks are the largest living turtles and range farther than any other sea turtle species. Their large size and tolerance of relatively low water temperatures allows them to occur in boreal waters such as those off Labrador and in the Barents Sea (NMFS and USFWS 1995).

In 1980, the leatherback population was estimated at approximately 115,000 adult females globally (Pritchard 1982). By 1995, this global population of adult females was estimated to have declined to 34,500 (Spotila *et al.* 1996). The most recent population size estimate for the North Atlantic alone is a range of 34,000-94,000 adult leatherbacks (TEWG 2007). Thus, there is substantial uncertainty with respect to global population estimates of leatherback sea turtles.

Pacific Ocean

Leatherback nesting has been declining at all major Pacific basin nesting beaches for the last two decades (Spotila *et al.* 1996, 2000; NMFS and USFWS 1998a, 2007b; Sarti *et al.* 2000). In the western Pacific, major nesting beaches occur in Papua New Guinea, Indonesia, Solomon Islands, and Vanuatu, with an approximate 2,700-4,500 total breeding females, estimated from nest counts (Dutton *et al.* 2007). While there appears to be overall long term population decline, the Indonesian nesting aggregation at Jamursba-Medi is currently stable (since 1999), although there is evidence to suggest a significant and continued decline in leatherback nesting in Papua New Guinea and Solomon Islands over the past 30 years (NMFS 2011). Leatherback sea turtles disappeared from India before 1930, have been virtually extinct in Sri Lanka since 1994, and appear to be approaching extinction in Malaysia (Spotila *et al.* 2000). In Fiji, Thailand, and Australia, leatherback sea turtles have only been known to nest in low densities and scattered sites.

The largest, extant leatherback nesting group in the Indo-Pacific lies on the North Vogelkop coast of West Papua, Indonesia, with 3,000-5,000 nests reported annually in the 1990s (Suárez *et al.* 2000). However, in 1999, local villagers started reporting dramatic declines in sea turtles near their villages (Suárez 1999). Declines in nesting groups have been reported throughout the

western Pacific region where observers report that nesting groups are well below abundance levels that were observed several decades ago (*e.g.*, Suárez 1999).

Leatherback sea turtles in the western Pacific are threatened by poaching of eggs, killing of nesting females, human encroachment on nesting beaches, incidental capture in fishing gear, beach erosion, and egg predation by animals.

In the eastern Pacific Ocean, major leatherback nesting beaches are located in Mexico and Costa Rica, where nest numbers have been declining. According to reports from the late 1970s and early 1980s, beaches located on the Mexican Pacific coasts of Michoacán, Guerrero, and Oaxaca sustained a large portion, perhaps 50%, of all global nesting by leatherbacks (Sarti *et al.* 1996). A dramatic decline has been seen on nesting beaches in Pacific Mexico, where aerial survey data was used to estimate that tens of thousands of leatherback nests were laid on the beaches in the 1980s (Pritchard 1982), but a total of only 120 nests on the four primary index beaches (combined) were counted in the 2003-2004 season (Sarti Martinez *et al.* 2007). Since the early 1980s, the Mexican Pacific population of adult female leatherback turtles has declined to slightly more than 200 during 1998-1999 and 1999-2000 (Sarti *et al.* 2000). Spotila *et al.* (2000) reported the decline of the leatherback nesting at Playa Grande, Costa Rica, which had been the fourth largest nesting group in the world and the most important nesting beach in the Pacific. Between 1988 and 1999, the nesting group declined from 1,367 to 117 female leatherback sea turtles. Based on their models, Spotila *et al.* (2000) estimated that the group could fall to less than 50 females by 2003-2004. Another, more recent, analysis of the Costa Rican nesting beaches indicates a decline in nesting during 15 years of monitoring (1989-2004) with approximately 1,504 females nesting in 1988-1989 to an average of 188 females nesting in 2000-2001 and 2003-2004 (NMFS and USFWS 2007b), indicating that the reductions in nesting females were not as extreme as the reductions predicted by Spotila *et al.* (2000).

On September 26, 2007, we received a petition to revise the critical habitat designation for leatherback sea turtles to include waters along the U.S. West Coast. On December 28, 2007, we published a positive 90-day finding on the petition and convened a critical habitat review team. On January 26, 2012, we published a final rule to revise the critical habitat designation to include three particular areas of marine habitat. The designation includes approximately 16,910 square miles along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour, and 25,004 square miles from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The areas comprise approximately 41,914 square miles of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet. The designated critical habitat areas contain the physical or biological feature essential to the conservation of the species that may require special management conservation or protection. In particular, the team identified one Primary Constituent Element: the occurrence of prey species, primarily scyphomedusae of the order Semaestomeae, of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

Leatherbacks in the eastern Pacific face a number of threats to their survival. For example, commercial and artisanal swordfish fisheries off Chile, Columbia, Ecuador, and Peru; purse

seine fisheries for tuna in the eastern tropical Pacific Ocean; and California/Oregon drift gillnet fisheries are known to capture, injure, or kill leatherbacks in the eastern Pacific Ocean. Given the declines in leatherback nesting in the Pacific, some researchers have concluded that the leatherback is on the verge of extinction in the Pacific Ocean (e.g., Spotila *et al.* 1996, 2000).

Indian Ocean

Leatherbacks nest in several areas around the Indian Ocean. These sites include Tongaland, South Africa (Pritchard 2002) and the Andaman and Nicobar Islands (Andrews *et al.* 2002). Intensive survey and tagging work in 2001 provided new information on the level of nesting in the Andaman and Nicobar Islands (Andrews *et al.* 2002). Based on the survey and tagging work, it was estimated that 400-500 female leatherbacks nest annually on Great Nicobar Island (Andrews *et al.* 2002). The number of nesting females using the Andaman and Nicobar Islands combined was estimated around 1,000 (Andrews and Shanker 2002). Some nesting also occurs along the coast of Sri Lanka, although in much smaller numbers than in the past (Pritchard 2002).

Mediterranean Sea

Casale *et al.* (2003) reviewed the distribution of leatherback sea turtles in the Mediterranean. Among the 411 individual records of leatherback sightings in the Mediterranean, there were no nesting records. Nesting in the Mediterranean is believed to be extremely rare if it occurs at all. Leatherbacks found in Mediterranean waters originate from the Atlantic Ocean (P. Dutton, NMFS, unpublished data).

Atlantic Ocean

Distribution and Life History

Evidence from tag returns and strandings in the western Atlantic suggests that adult leatherback sea turtles engage in routine migrations between northern temperate and tropical waters (NMFS and USFWS 1992). Leatherbacks are frequently thought of as a pelagic species that feed on jellyfish (e.g., *Stomolophus*, *Chrysaora*, and *Aurelia* species) and tunicates (e.g., salps, pyrosomas) (Rebel 1974; Davenport and Balazs 1991). However, leatherbacks are also known to use coastal waters of the U.S. continental shelf (James *et al.* 2005a; Eckert *et al.* 2006; Murphy *et al.* 2006), as well as the European continental shelf on a seasonal basis (Witt *et al.* 2007).

Tagging and satellite telemetry data indicate that leatherbacks from the western North Atlantic nesting beaches use the entire North Atlantic Ocean (TEWG 2007). For example, leatherbacks tagged at nesting beaches in Costa Rica have been found in Texas, Florida, South Carolina, Delaware, and New York (STSSN database). Leatherback sea turtles tagged in Puerto Rico, Trinidad, and the Virgin Islands have also been subsequently found on U.S. beaches of southern, Mid-Atlantic, and northern states (STSSN database). Leatherbacks from the South Atlantic nesting assemblages (West Africa, South Africa, and Brazil) have not been re-sighted in the western North Atlantic (TEWG 2007).

The CETAP aerial survey of the outer Continental Shelf from Cape Hatteras, North Carolina to Cape Sable, Nova Scotia conducted between 1978 and 1982 showed leatherbacks to be present throughout the area with the most numerous sightings made from the Gulf of Maine south to

Long Island. Leatherbacks were sighted in water depths ranging from 1 to 4,151 m, but 84.4% of sightings were in waters less than 180 m (Shoop and Kenney 1992). Leatherbacks were sighted in waters within a sea surface temperature range similar to that observed for loggerheads; from 7°-27.2°C (Shoop and Kenney 1992). However, leatherbacks appear to have a greater tolerance for colder waters in comparison to loggerhead sea turtles since more leatherbacks were found at the lower temperatures (Shoop and Kenney 1992). Studies of satellite tagged leatherbacks suggest that they spend 10%-41% of their time at the surface, depending on the phase of their migratory cycle (James *et al.* 2005b). The greatest amount of surface time (up to 41%) was recorded when leatherbacks occurred in continental shelf and slope waters north of 38°N (James *et al.* 2005b).

In 1979, the waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands were designated as critical habitat for the leatherback sea turtle. On February 2, 2010, we received a petition to revise the critical habitat designation for leatherback sea turtles to include waters adjacent to a major nesting beach in Puerto Rico. We published a 90-day finding on the petition on July 16, 2010, which found that the petition did not present substantial scientific information indicating that the petitioned revision was warranted. The original petitioners submitted a second petition on November 2, 2010 to revise the critical habitat designation to again include waters adjacent to a major nesting beach in Puerto Rico, including additional information on the usage of the waters. We determined on May 5, 2011, that a revision to critical habitat off Puerto Rico may be warranted, and an analysis is underway. Note that on August 4, 2011, FWS issued a determination that revision to critical habitat along Puerto Rico should be made and will be addressed during the future planned status review.

Leatherbacks are a long lived species (>30 years). They were originally believed to mature at a younger age than loggerhead sea turtles, with a previous estimated age at sexual maturity of about 13-14 years for females with 9 years reported as a likely minimum (Zug and Parham 1996) and 19 years as a likely maximum (NMFS SEFSC 2001). However, new sophisticated analyses suggest that leatherbacks in the Northwest Atlantic may reach maturity at 24.5-29 years of age (Avens *et al.* 2009). In the United States and Caribbean, female leatherbacks nest from March through July. In the Atlantic, most nesting females average between 150-160 cm curved carapace length (CCL), although smaller (<145 cm CCL) and larger nesters are observed (Stewart *et al.* 2007, TEWG 2007). They nest frequently (up to seven nests per year) during a nesting season and nest about every 2-3 years. They produce 100 eggs or more in each clutch and can produce 700 eggs or more per nesting season (Schultz 1975). However, a significant portion (up to approximately 30%) of the eggs can be infertile. Therefore, the actual proportion of eggs that can result in hatchlings is less than the total number of eggs produced per season. As is the case with other sea turtle species, leatherback hatchlings enter the water soon after hatching. Based on a review of all sightings of leatherback sea turtles of <145 cm CCL, Eckert (1999) found that leatherback juveniles remain in waters warmer than 26°C until they exceed 100 cm CCL.

Population Dynamics and Status

As described earlier, sea turtle nesting survey data is important in that it provides information on the relative abundance of nesting, and the contribution of each population/subpopulation to total nesting of the species. Nest counts can also be used to estimate the number of reproductively

mature females nesting annually, and as an indicator of the trend in the number of nesting females in the nesting group. The 5-year review for leatherback sea turtles (NMFS and USFWS 2007b) compiled the most recent information on mean number of leatherback nests per year for each of the seven leatherback populations or groups of populations that were identified by the Leatherback TEWG as occurring within the Atlantic. These are: Florida, North Caribbean, Western Caribbean, Southern Caribbean, West Africa, South Africa, and Brazil (TEWG 2007).

In the United States, the Florida Statewide Nesting Beach Survey program has documented an increase in leatherback nesting numbers from 98 nests in 1988 to between 800 and 900 nests in the early 2000s (NMFS and USFWS 2007b). Stewart *et al.* (2011) evaluated nest counts from 68 Florida beaches over 30 years (1979-2008) and found that nesting increased at all beaches with trends ranging from 3.1%-16.3% per year, with an overall increase of 10.2% per year. An analysis of Florida's index nesting beach sites from 1989-2006 shows a substantial increase in leatherback nesting in Florida during this time, with an annual growth rate of approximately 1.17 (TEWG 2007). The TEWG reports an increasing or stable nesting trend for all of the seven populations or groups of populations with the exception of the Western Caribbean and West Africa. The leatherback rookery along the northern coast of South America in French Guiana and Suriname supports the majority of leatherback nesting in the western Atlantic (TEWG 2007), and represents more than half of total nesting by leatherback sea turtles worldwide (Hilterman and Goverse 2004). Nest numbers in Suriname have shown an increase and the long-term trend for the Suriname and French Guiana nesting group seems to show an increase (Hilterman and Goverse 2004). In 2001, the number of nests for Suriname and French Guiana combined was 60,000, one of the highest numbers observed for this region in 35 years (Hilterman and Goverse 2004). The TEWG (2007) report indicates that using nest numbers from 1967-2005, a positive population growth rate was found over the 39-year period for French Guinea and Suriname, with a 95% probability that the population was growing. Given the magnitude of leatherback nesting in this area compared to other nest sites, negative impacts in leatherback sea turtles in this area could have profound impacts on the entire species.

The CETAP aerial survey conducted from 1978-1982 estimated the summer leatherback population for the northeastern United States at approximately 300-600 animals (from near Nova Scotia, Canada to Cape Hatteras, North Carolina) (Shoop and Kenney 1992). However, the estimate was based on turtles visible at the surface and does not include those that were below the surface out of view. Therefore, it likely underestimated the leatherback population for the northeastern United States at the time of the survey. Estimates of leatherback abundance of 1,052 turtles (C.V. = 0.38) and 1,174 turtles (C.V. = 0.52) were obtained from surveys conducted from Virginia to the Gulf of St. Lawrence in 1995 and 1998, respectively (Palka 2000). However, since these estimates were also based on sightings of leatherbacks at the surface, the author considered the estimates to be negatively biased and the true abundance of leatherbacks may be 4.27 times higher (Palka 2000).

Threats

The 5-year status review (NMFS and USFWS 2007b) and TEWG (2007) report provide summaries of natural as well as anthropogenic threats to leatherback sea turtles. Of the Atlantic sea turtle species, leatherbacks seem to be the most vulnerable to entanglement in fishing gear,

trap/pot gear in particular. This susceptibility may be the result of their body type (large size, long pectoral flippers, and lack of a hard shell), their diving and foraging behavior, their distributional overlap with the gear, their possible attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface, and perhaps to the lightsticks used to attract target species in longline fisheries. Leatherbacks entangled in fishing gear generally have a reduced ability to feed, dive, surface to breathe, or perform any other behavior essential to survival (Balazs 1985). In addition to drowning from forced submergence, they may be more susceptible to boat strikes if forced to remain at the surface, and entangling lines can constrict blood flow resulting in tissue necrosis. The long-term impacts of entanglement on leatherback health remain unclear. Innis *et al.* (2010) conducted a health evaluation of leatherback sea turtles during direct capture (n=12) and disentanglement (n=7). They found no significant difference in many of the measured health parameters between entangled and directly captured turtles. However, blood parameters, including but not limited to sodium, chloride, and blood urea nitrogen, for entangled turtles showed several key differences that were most likely due to reduced foraging and associated seawater ingestion, as well as a general stress response.

Finkbeiner *et al.* (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. Information was obtained from peer reviewed publications and NMFS documents (e.g., Biological Opinions and bycatch reports). In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). The Southeast/Gulf of Mexico shrimp trawl fishery was responsible for the vast majority of U.S. interactions (up to 98%) and mortalities (more than 80%). While this provides an initial cumulative bycatch assessment, there are a number of caveats that should be considered when interpreting this information, such as sampling inconsistencies and limitations.

Leatherbacks have been documented interacting with longline, trap/pot, trawl, and gillnet fishing gear. For instance, an estimated 6,363 leatherback sea turtles were documented as caught by the U.S. Atlantic tuna and swordfish longline fisheries between 1992-1999 (NMFS SEFSC 2001). Currently, the U.S. tuna and swordfish longline fisheries managed under the HMS FMP are estimated to capture 1,764 leatherbacks (no more than 252 mortalities) for each 3-year period starting in 2007 (NMFS 2004a). In 2010, there were 26 observed interactions between leatherback sea turtles and longline gear used in the HMS fishery (Garrison and Stokes 2011a, 2011b). All leatherbacks were released alive, with all gear removed for the majority of captures. While 2010 total estimates are not yet available, in 2009, 285.8 (95% CI: 209.6-389.7) leatherback sea turtles are estimated to have been taken in the longline fisheries managed under the HMS FMP based on the observed takes (Garrison and Stokes 2010). The 2009 estimate continues a downward trend since 2007 and remains well below the average prior to implementation of gear regulations (Garrison and Stokes 2010). Since the U.S. fleet accounts for only 5%-8% of the longline hooks fished in the Atlantic Ocean, adding up the under-represented observed takes of the other 23 countries actively fishing in the area would likely result in annual take estimates of thousands of leatherbacks over different life stages (NMFS SEFSC 2001). Lewison *et al.* (2004) estimated that 30,000-60,000 leatherbacks were taken in all Atlantic

longline fisheries in 2000 (including the U.S. Atlantic tuna and swordfish longline fisheries, as well as others).

Leatherbacks are susceptible to entanglement in the lines associated with trap/pot gear used in several fisheries. From 1990-2000, 92 entangled leatherbacks were reported from New York through Maine (Dwyer *et al.* 2002). Additional leatherbacks stranded wrapped in line of unknown origin or with evidence of a past entanglement (Dwyer *et al.* 2002). More recently, from 2002 to 2010, NMFS received 137 reports of sea turtles entangled in vertical lines from Maine to Virginia, with 128 events confirmed (verified by photo documentation or response by a trained responder; NMFS 2008a). Of the 128 confirmed events during this period, 117 events involved leatherbacks. NMFS identified the gear type and fishery for 72 of the 117 confirmed events, which included lobster (42⁶), whelk/conch (15), black sea bass (10), crab (2), and research pot gear (1). A review of leatherback mortality documented by the STSSN in Massachusetts suggests that vessel strikes and entanglement in fixed gear (primarily lobster pots and whelk pots) are the principal sources of this mortality (Dwyer *et al.* 2002).

Leatherback interactions with the U.S. South Atlantic and Gulf of Mexico shrimp fisheries are also known to occur (NMFS 2002). Leatherbacks are likely to encounter shrimp trawls working in the coastal waters off the U.S. Atlantic coast (from Cape Canaveral, Florida through North Carolina) as they make their annual spring migration north. For many years, TEDs that were required for use in the U.S. South Atlantic and Gulf of Mexico shrimp fisheries were less effective for leatherbacks as compared to the smaller, hard-shelled turtle species, because the TED openings were too small to allow leatherbacks to escape. To address this problem, NMFS issued a final rule on February 21, 2003, to amend the TED regulations (68 FR 8456, February 21, 2003). Modifications to the design of TEDs are now required in order to exclude leatherbacks as well as large benthic immature and sexually mature loggerhead and green sea turtles. Given those modifications, Epperly *et al.* (2002) anticipated an average of 80 leatherback mortalities a year in shrimp gear interactions, dropping to an estimate of 26 leatherback mortalities in 2009 due to effort reduction in the Southeast shrimp fishery (Memo from Dr. B. Ponwith, SEFSC, to Dr. R. Crabtree, SERO, January 5, 2011).

Other trawl fisheries are also known to interact with leatherback sea turtles although on a much smaller scale. In October 2001, for example, a NMFS fisheries observer documented the take of a leatherback in a bottom otter trawl fishing for *Loligo* squid off of Delaware. TEDs are not currently required in this fishery. In November 2007, fisheries observers reported the capture of a leatherback sea turtle in bottom otter trawl gear fishing for summer flounder.

Gillnet fisheries operating in the waters of the Mid-Atlantic states are also known to capture, injure, and/or kill leatherbacks when these fisheries and leatherbacks co-occur. Data collected by the NEFSC Fisheries Observer Program from 1994-1998 (excluding 1997) indicate that a total of 37 leatherbacks were incidentally captured (16 lethally) in drift gillnets set in offshore waters from Maine to Florida during this period. Observer coverage for this period ranged from 54%-92%. In North Carolina, six additional leatherbacks were reported captured in gillnet sets in the

⁶ One case involved both lobster and whelk/conch gear.

spring (NMFS SEFSC 2001). In addition to these, in September 1995, two dead leatherbacks were removed from an 11-inch (28.2-cm) monofilament shark gillnet set in the nearshore waters off of Cape Hatteras (STSSN unpublished data reported in NMFS SEFSC 2001). Lastly, Murray (2009a) reports five observed leatherback captures in Mid-Atlantic sink gillnet fisheries between 1994 and 2008.

Fishing gear interactions can occur throughout the range of leatherbacks. Entanglements occur in Canadian waters where Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland/Labrador were entangled in fishing gear including salmon net, herring net, gillnet, trawl line, and crab pot line. Leatherbacks are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Castroviejo *et al.* 1994; Graff 1995). Gillnets are one of the suspected causes for the decline in the leatherback sea turtle population in French Guiana (Chevalier *et al.* 1999), and gillnets targeting green and hawksbill sea turtles in the waters of coastal Nicaragua also incidentally catch leatherback sea turtles (Lagueux *et al.* 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alio-M. 2000). An estimated 1,000 mature female leatherback sea turtles are caught annually in fishing nets off of Trinidad and Tobago with mortality estimated to be between 50%-95% (Eckert and Lien 1999). Many of the sea turtles do not die as a result of drowning, but rather because the fishermen cut them out of their nets (NMFS SEFSC 2001).

Leatherbacks may be more susceptible to marine debris ingestion than other sea turtle species due to the tendency of floating debris to concentrate in convergence zones that juveniles and adults use for feeding (Shoop and Kenney 1992; Lutcavage *et al.* 1997). Investigations of the necropsy results of leatherback sea turtles revealed that a substantial percentage (34% of the 408 leatherback necropsies' recorded between 1885 and 2007) reported plastic within the turtles' stomach contents, and in some cases (8.7% of those cases in which plastic was reported), blockage of the gut was found in a manner that may have caused the mortality (Mrosovsky *et al.* 2009). An increase in reports of plastic ingestion was evident in leatherback necropsies conducted after the late 1960s (Mrosovsky *et al.* 2009). Along the coast of Peru, intestinal contents of 19 of 140 (13%) leatherback carcasses were found to contain plastic bags and film (Fritts 1982). The presence of plastic debris in the digestive tract suggests that leatherbacks might not be able to distinguish between prey items (*e.g.*, jellyfish) and plastic debris (Mrosovsky 1981). Balazs (1985) speculated that plastic objects may resemble food items by their shape, color, size, or even movements as they drift about, and induce a feeding response in leatherbacks.

Summary of Status for Leatherback Sea Turtles

In the Pacific Ocean, the abundance of leatherback sea turtles on nesting beaches has declined dramatically over the past 10 to 20 years. Nesting groups throughout the eastern and western Pacific Ocean have been reduced to a fraction of their former abundance by the combined effects of human activities that have reduced the number of nesting females and reduced the reproductive success of females that manage to nest (for example, egg poaching) (NMFS and USFWS 2007b). No reliable long term trend data for the Indian Ocean populations are currently

available. While leatherbacks are known to occur in the Mediterranean Sea, nesting in this region is not known to occur (NMFS and USFWS 2007b).

Nest counts in many areas of the Atlantic Ocean show increasing trends, including for beaches in Suriname and French Guiana which support the majority of leatherback nesting (NMFS and USFWS 2007b). The species as a whole continues to face numerous threats in nesting and marine habitats. As with the other sea turtle species, fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches, while other activities like pollution and habitat destruction account for an unknown level of other mortality. The long term recovery potential of this species may be further threatened by observed low genetic diversity, even in the largest nesting groups like French Guiana and Suriname (NMFS and USFWS 2007b).

Based on its 5-year status review of the species, NMFS and USFWS (2007b) determined that endangered leatherback sea turtles should not be delisted or reclassified. However, it was also determined that an analysis and review of the species should be conducted in the future to determine whether DPSs should be identified (NMFS and USFWS 2007b).

4.6 Shortnose Sturgeon

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, chironomids, isopods), 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)⁷ 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

⁷ 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.

sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell *et al.* 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NMFS 1998). Thus, annual egg production is likely to vary greatly in this species. Fecundity estimates have been made and range from 27,000 to 208,000 eggs/female and a mean of 11,568 eggs/kg body weight (Dadswell *et al.* 1984).

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days after hatching in comparison to Savannah River larvae that had longer dispersal rates with multiple, prolonged peaks, and a low level of downstream movement that continued throughout the entire larval and early juvenile period (Parker 2007). Synder (1988) and Parker (2007) considered individuals to be juvenile when they reached 57mm TL. Laboratory studies demonstrated that larvae from the Connecticut River made this transformation on day 40 while Savannah River fish made this transition on day 41 and 42 (Parker 2007).

The juvenile phase can be subdivided in to young of the year (YOY) and immature/ sub-adults. YOY and sub-adult habitat use differs and is believed to be a function of differences in salinity tolerances. Little is known about YOY behavior and habitat use, though it is believed that they are typically found in channel areas within freshwater habitats upstream of the saltwedge 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). However, 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, 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°, 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° and 12°C, 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 (Dadswell *et al.* 1984) and as high as 34°C (Heidt and Gilbert 1978). However, temperatures above 28°C are thought to adversely affect shortnose sturgeon. In the Altamaha River, temperatures of 28-30°C 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 is necessary for the unimpeded swimming by adults. Shortnose sturgeon are known to occur at depths of up to 30m but are generally found in waters less than 20m (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).

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)⁸ 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 comprised of breeding subpopulations (NMFS 1998).

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

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

⁸ 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.

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 or the shortnose sturgeon population in the Northeastern United States exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed.

Threats to shortnose sturgeon recovery

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). Bridge 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 water quality 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 semi-volatile 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 semi-volatile 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 (Flourney *et al.* 1992). At these temperatures, concomitant low levels of dissolved oxygen may be lethal.

4.7 Status of Atlantic sturgeon

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon, and provides information specific to the status of each DPS of 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, FL (Scott and Scott 1988; ASSRT 2007;). We have divided U.S. populations of Atlantic sturgeon into five DPSs⁹ (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 2**Error! Reference source not found.**).

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 that sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine, and riverine environment that occur far from natal spawning rivers.

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, fish that originated in Canada are not included in the listings.

Atlantic Sturgeon Life History

Atlantic sturgeon are long-lived (approximately 60 years), late maturing, estuarine dependent, anadromous¹⁰ fish (Bigelow and Schroeder 1953; Vladykov and Greeley 1963; Mangin 1964;

9 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.”

10 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 FAQs, available at <http://www.nefsc.noaa.gov/faq/fishfaq1a.html>, modified June 16, 2011)

Pikitch *et al.* 2005; Dadswell 2006; ASSRT 2007).

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

Table 5: Atlantic sturgeon life history

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

Atlantic sturgeon can grow to over 14 feet weighing 800 pounds (Pikitch *et al.* 2005). Atlantic sturgeon are bottom feeders that suck food into a ventral 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 subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder 1953; ASSRT 2007; Guilbard *et al.* 2007; Savoy 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder 1953; ASSRT 2007; Guilbard *et al.* 2007).

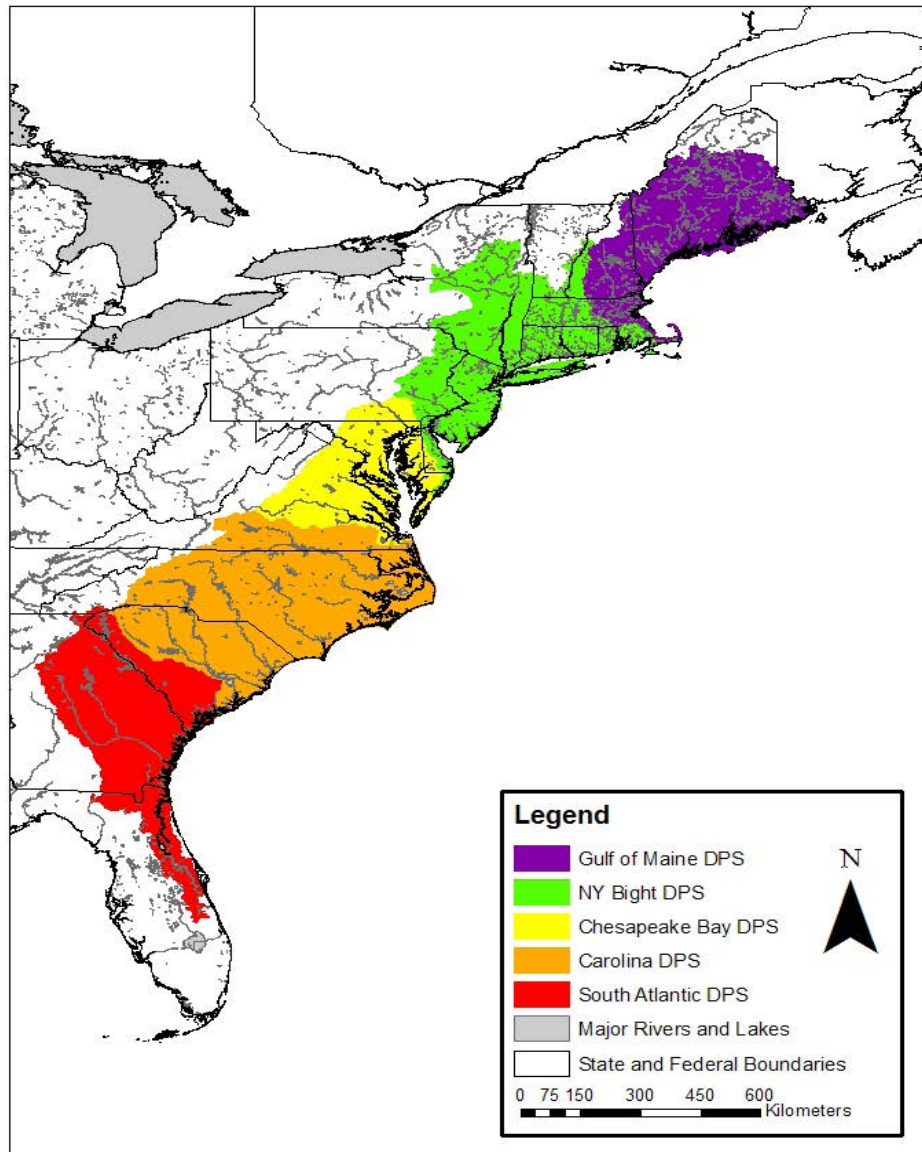


Figure 2: Map Depicting the Boundaries of the five Atlantic sturgeon DPSs

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. The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 meters (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). The lengths of Atlantic sturgeon caught since the mid-late 20th century have typically been less than three meters (Smith *et al.* 1982; Smith and Dingley 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). While females are prolific, with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of two to five years (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% of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman 1997). Males exhibit spawning periodicity of one to five years (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° 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 centimeters per second and depths are 3-27 meters (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 1984; 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 four weeks old, with total lengths (TL) less than 30 millimeters; Van Eenennaam *et al.* 1996) are assumed to mostly live on or near the bottom and inhabit the same riverine or estuarine areas where they were spawned (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 both high salinity and 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 Berggren 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 meters 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.* 2004a; 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 meters during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 meters 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, NC 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, with the majority of these tag returns from relatively shallow nearshore fisheries, with few fish reported from waters in excess of 25 meters (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC 2009). Areas where 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 meters (Dovel and Berggren 1983; Dadswell *et al.* 1984; Johnson *et al.* 1997; Rochard *et al.* 1997; Kynard *et al.* 2000; Eyster *et al.* 2004; Stein *et al.* 2004a; Wehrell 2005; Dadswell 2006; ASSRT 2007; Laney *et al.* 2007). These sites may be used as foraging sites and/or thermal refuge.

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 River, and at least 10,000 females for other spawning stocks (Secor and Waldman 1999; Secor 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. In the status review (ASSRT 2007), we noted that 17 U.S. rivers were known to support spawning (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years). Since the status review was completed, new information indicates that spawning occurs in the Androscoggin River (Maine), the York River system (Virginia), Northeast Cape Fear and Black River. The recent capture of age-0 Atlantic sturgeon in the Connecticut River indicates that spawning, at least in some years, is most likely occurring in the Connecticut.

Spawning may also occur in other rivers in the Chesapeake Bay (e.g., Marshyhope Creek) and in the southeast (St. Marys). Despite evidence that spawning occurs in additional rivers than known at the time of the status review, the number of rivers supporting spawning of Atlantic sturgeon is significantly fewer than it was historically and the number of spawning adults, and presumably young, is a fraction of historic levels. Further, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could make recolonization of extirpated populations more difficult.

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

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NEFSC developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (see Kocik *et al.* 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (Table 6). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the United States Fish and Wildlife Service (FWS) sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. FWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag, release, and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery vessels.

In addition to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 7). NEAMAP trawl surveys are conducted from

Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall since 2007 and spring since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations. The ASMFC has initiated a new stock assessment with the goal of completing it in 2017. We are partnering with them to conduct the stock assessment, and the methodology to produce the ocean population abundance estimates used by the NEFSC will be shared with the stock assessment committee for consideration in the stock assessment.

Table 6: Description of the ASPI model and NEAMAP survey based area estimate method

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

Table 7: Modeled results

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

The information from the NEAMAP survey can be used to calculate minimum swept area population estimates within the strata swept by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 8). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e. net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are within the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most

species. The ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, but is certainly greater than one (i.e. the NEAMAP survey does not survey 100% of the Atlantic sturgeon habitat).

Table 8: Annual minimum swept area estimates for Atlantic sturgeon during the spring and fall from the Northeast Area Monitoring and Assessment Program survey *

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

*Estimates assume 100% net efficiencies. Estimates provided by Dr. Chris Bonzek, Virginia Institute of Marine Science (VIMS).

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

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

The ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey (see Table 7). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from FWS sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The NEAMAP estimate, in contrast, does not depend on as many assumptions. For the purposes of this Opinion, we consider the NEAMAP estimate resulting from the 50% catchability rate is the best available information on the number of subadult and adult Atlantic sturgeon in the ocean. .

The ocean population abundance of 67,776 fish estimated from the NEAMAP survey assuming 50% efficiency (based on net efficiency and the fraction of the total population exposed to the survey) was subsequently partitioned by DPS based on genetic frequencies of occurrence (Table 9) in the sampled area. Given the proportion of adults to subadults in the observer database (approximate ratio of 1:3), we have also estimated a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults.

Table 9: Summary of calculated population estimates based upon the NEAMAP Survey swept area assuming 50% efficiency *

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

*Based on net efficiency and area sampled, derived from applying the Mixed Stock Analysis to the total estimate of Atlantic sturgeon in the Ocean and the 1:3 ratio of adults to subadults

Threats Faced by Atlantic Sturgeon throughout Their Range

Atlantic sturgeon are susceptible to over-exploitation given their life history characteristics (e.g., late maturity and dependence on a wide variety of habitats). Similar to other sturgeon species

(Vladykov and Greeley 1963; Pikitch *et al.* 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub 1990; Smith and Clugston 1997; Secor and Waldman 1999).

Because a DPS is a group of populations, the stability, viability, and persistence of individual populations that make up the DPS affects the persistence and viability of the larger DPS. The loss of any population within a DPS could result in: (1) a long-term gap in the range of the DPS that is unlikely to be recolonized; (2) loss of reproducing individuals; (3) loss of genetic biodiversity; (4) loss of unique haplotypes; (5) loss of adaptive traits; and (6) reduction in total number. The loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (Secor and Waldman 1999). The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, emigration to marine habitats to grow, and return of adults to natal rivers to spawn.

Based on the best available information, we concluded that bycatch in fisheries, vessel strikes, poor water quality, fresh 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 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 Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, because Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

Atlantic sturgeon are particularly sensitive to bycatch mortality because they are a long-lived species, have an older age at maturity, have lower maximum fecundity values, and a large percentage of egg production occurs later in life. Based on these life history traits, Boreman (1997) calculated that Atlantic sturgeon can only withstand the annual loss of up to 5% of their population to bycatch mortality without suffering population declines. Mortality rates of Atlantic sturgeon taken as bycatch in various types of fishing gear range are variable with the greatest mortality occurring in sturgeon caught by sink gillnets. Atlantic sturgeon are particularly vulnerable to being caught in sink gillnets; therefore, fisheries using this type of gear account for a high percentage of Atlantic sturgeon bycatch. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or may result in delayed post-capture mortality.

As a wide-ranging anadromous species, Atlantic sturgeon are subject to numerous federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency

activities. While these mechanisms, including the prohibition on possession, have addressed impacts to Atlantic sturgeon through directed fisheries, the listing determination concluded that the mechanisms in place to address the risk posed to Atlantic sturgeon from commercial bycatch were insufficient.

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 their parts in or from the EEZ 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 captured in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year. Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

Bycatch in U.S. waters is one of the threats faced by all five 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 2011b) in the Greater Atlantic 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 DPSs. This is because of (1) the small number of data points and, (2) the lack of information on the percent of incidents 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 (NMFS NEFSC 2011b). The analysis estimates that from 2006 through 2010, there were averages of 1,548 and 1,569 encounters per year in observed gillnet and trawl fisheries, respectively, with an average of 3,118 encounters combined annually. Mortality rates in gillnet gear were approximately 20%. Mortality rates in otter trawl gear are generally lower, at approximately 5%.

4.7.2 Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Delaware River and estuary. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Delaware River, and thereby, in the action area, will have originated from the Delaware River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Delaware River and estuary would not be limited to just individuals originating from the NYB DPS. Based on mixed-stock analysis, we have determined that subadult and adult Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: Gulf of Maine 7%; NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; and Carolina 0.5%. These percentages are largely based on genetic sampling of individuals (n=105) sampled in directed research targeting Atlantic sturgeon along the Delaware Coast, just south of Delaware Bay. This is the closest sampling effort (geographically) to the action area for which mixed stock analysis results are available. Because the genetic composition of the mixed stock changes with distance from the rivers of origin, it is appropriate to use mixed stock analysis results from the nearest sampling location. Therefore, this represents the best available information on the likely genetic makeup of individuals occurring in the action area.

We also considered information on the genetic makeup of subadults and adults captured within the Delaware River. However, we only have information on the assignment of these individuals to the river of origin and do not have a mixed stock analysis for these samples. The river assignments are very similar to the mixed stock analysis results for the Delaware Coastal sampling, with the Hudson/Delaware accounting for 55-61% of the fish, James River accounting for 17-18%, Savannah/Ogeechee/Altamaha 17-18%, and Kennebec 9-11%. The range in assignments considers the slightly different percentages calculated by treating each sample individually versus treating each fish individually (some fish were captured in more than one of the years during the three year study). Carolina DPS origin fish have rarely been detected in samples taken in the Northeast and are not detected in either the Delaware Coast or in-river samples noted above. However, mixed stock analysis from one sampling effort (i.e., Long Island Sound, n=275), indicates that approximately 0.5% of the fish sampled were Carolina DPS origin. Additionally, 4% of Atlantic sturgeon captured incidentally in commercial fisheries along the U.S. Atlantic coast north of Cape Hatteras, and genetically analyzed, belong to the Carolina DPS. Because any Carolina origin sturgeon that were sampled in Long Island Sound could have swam through the action area on their way between Long Island Sound and their rivers of origin, it is reasonable to expect that 0.5% of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. 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).

4.8 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning still occurs in the Kennebec River, and it is possible that it still occurs in the Penobscot River as well. Recent evidence indicates that spawning may also be occurring in the Androscoggin River. During the 2011 spawning season, the Maine Department of Marine Resources captured a larval Atlantic sturgeon 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 1880s, 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 occur. 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 Greater Atlantic FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

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

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at a dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam, sturgeon can now travel as far upstream as the Great Works Dam. The Great Works Dam prevents Atlantic sturgeon from accessing the presumed historical spawning habitat located downstream of Milford Falls, the site of the Milford Dam. While removal of the Great Works Dams is anticipated to occur in the near future, the presence of this dam is currently preventing access to significant habitats within the Penobscot River. While Atlantic sturgeon are known to occur in the Penobscot River, it is unknown if spawning is currently occurring or whether the presence of the Great Works Dam 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.

Summary of the Gulf of Maine DPS

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

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

Gulf of Maine DPS (Wirgin *et al.*, in draft).

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

4.9 New York Bight DPS of Atlantic sturgeon

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco, 1977; Secor, 2002; ASSRT, 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Taunton River (ASSRT, 2007). In June 2014, several presumed age-0 Atlantic sturgeon were captured in the Connecticut River (T. Savoy, CT DEEP, pers. comm.). These captures represent the only contemporary records of possible natal Atlantic sturgeon in the Connecticut River. Capture of age-0 Atlantic sturgeon strongly suggests that spawning is occurring in that river (T. Savoy, CT DEEP, pers. comm.; Connecticut Weekly Diadromous Fish Report, May 20, 2014). Genetic analysis of tissues collected from these individuals is not yet available and will help to determine if these individuals represent a unique Connecticut River Atlantic sturgeon spawning population. The capture of these individuals follows the documentation of a dead adult Atlantic sturgeon in the river in May 2014. Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800s is unknown but, has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor, 2002; ASSRT, 2007; Kahnle *et al.*, 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). Kahnle *et al.* (1998; 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid-1970s (Kahnle *et al.*, 1998). A decline appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (Kahnle *et al.*, 1998; Sweka *et al.*, 2007; ASMFC, 2010). Catch-per-unit-effort data suggests that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980s (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 although the CPUE is generally higher in the 2000s as compared to the 1990s. Given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. In addition to bycatch mortality in Federal waters, bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (shad), has now been closed, and there is no indication that it will reopen soon. In the Hudson River sources of potential mortality include vessel strikes and entrainment in dredges. Individuals are also exposed to effects of bridge construction (including the ongoing replacement of the Tappan Zee Bridge). Impingement at water intakes, including the Danskammer, Roseton and Indian Point power plants also occurs. There is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

Most Atlantic sturgeon captured within tidal waters or freshwater in Connecticut are thought to be migrant subadults from the Hudson River (ASSRT 2007). Based on the lack of evidence of spawning adults, the Atlantic sturgeon status review team determined stocks of Atlantic sturgeon native to Connecticut waters are extirpated (ASSRT 2007). However, as noted above, in June 2014, several presumed age-0 Atlantic sturgeon were captured in the Connecticut River (T. Savoy, CT DEEP, pers. comm.). These captures represent the only contemporary records of possible natal Atlantic sturgeon in the Connecticut River. Capture of age-0 Atlantic sturgeon strongly suggests that spawning is occurring in that river (T. Savoy, CT DEEP, pers. comm.; Connecticut Weekly Diadromous Fish Report, May 20, 2014 No estimate of the number of spawning adults is available.

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

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

Summary of the New York Bight DPS

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

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). 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. Details of all documented interactions between dredges and Atlantic sturgeon are presented in section 7.0 below. A number of Atlantic sturgeon are killed during dredging operations each year; to date, the number reported to us has been less than 10 annually. At this time, we are 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 are known to occur in both the Delaware and Hudson Rivers. 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. We have determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.10 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT, 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT, 2007). Spawning occurs in the James River and recently was confirmed in the Pamunkey River (a tributary to the York River) (Musick *et al.*, 1994; ASSRT, 2007; Greene, 2009; Kahn *et al.* 2014; Hager *et al.* 2014). The presence of adult sturgeon suggests that spawning may also occur in Marshyhope Creek (a tributary to the Nanticoke River in Maryland). Investigations of spawning are also ongoing in the Mattaponi River where adult sturgeon have been observed. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

Age to maturity for Chesapeake Bay DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to

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

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

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

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

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

Summary of the Chesapeake Bay DPS

Spawning for the Chesapeake Bay DPS is known to occur in the James River and in the Pamunkey (York River system). Spawning may be occurring in other rivers, such as Marshyhope Creek (Nanticoke) and the Mattaponi, but has not been confirmed. There are anecdotal reports of increased sightings and captures of Atlantic sturgeon in the James River. However, this

information has not been comprehensive enough to develop a population estimate for the James River or to provide sufficient evidence to confirm increased abundance. Some of the impact from the threats that facilitated the decline of the Chesapeake Bay DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). We do not currently have enough information about any life stage to establish a trend for this DPS.

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

4.11 Carolina DPS of Atlantic sturgeon

The Carolina DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) from Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. Sturgeon are commonly captured 40 miles (64 km) offshore (D. Fox, DSU, pers. comm.). Records providing fishery bycatch data by depth show the vast majority of Atlantic sturgeon bycatch via gillnets is observed in waters less than 50 meters deep (Stein *et al.* 2004, ASMFC 2007), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms.

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. We determined spawning was occurring if young-of-the-year (YOY) were observed, or mature adults were present, in freshwater portions of a system (Table 10). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. There may also be spawning populations in the Neuse, Santee and Cooper Rivers, though it is uncertain. Historically, both the Sampit and Ashley Rivers were documented to have spawning populations at one time. However, the spawning population in the Sampit River is believed to be extirpated and the current status of the spawning population in the Ashley River is unknown. Both rivers may be used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems utilized by the Carolina DPS for specific life functions, such as spawning, nursery habitat, and foraging. However, fish from the Carolina DPS likely use other river systems than those listed here for their specific life functions.

Table 10: Major rivers, tributaries, and sounds within the range of the Carolina DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system

River/Estuary	Spawning Population	Data
Roanoke River, VA/NC; Albemarle Sound, NC	Yes	collection of 15 YOY (1997-1998); single YOY (2005)
Tar-Pamlico River, NC; Pamlico Sound	Yes	one YOY (2005)
Neuse River, NC; Pamlico Sound	Unknown	
Cape Fear River, NC	Yes	upstream migration of adults in the fall, carcass of a ripe female upstream in mid-September (2006)
Waccamaw River, SC; Winyah Bay	Yes	age-1, potentially YOY (1980s)
Pee Dee River, SC; Winyah Bay	Yes	running ripe male in Great Pee Dee River (2003)
Sampit, SC; Winyah Bay	Extirpated	
Santee River, SC	Unknown	
Cooper River, SC	Unknown	
Ashley River, SC	Unknown	

The riverine spawning habitat of the Carolina DPS occurs within the Mid-Atlantic Coastal Plain ecoregion (TNC 2002a), which includes bottomland hardwood forests, swamps, and some of the world's most active coastal dunes, sounds, and estuaries. Natural fires, floods, and storms are so dominant in this region that the landscape changes very quickly. Rivers routinely change their courses and emerge from their banks. The primary threats to biological diversity in the Mid-Atlantic Coastal Plain, as listed by TNC are: global climate change and rising sea level; altered surface hydrology and landform alteration (e.g., flood-control and hydroelectric dams, inter-basin transfers of water, drainage ditches, breached levees, artificial levees, dredged inlets and river channels, beach renourishment, and spoil deposition banks and piles); a regionally receding water table, probably resulting from both over-use and inadequate recharge; fire suppression; land fragmentation, mainly by highway development; land-use conversion (e.g., from forests to timber plantations, farms, golf courses, housing developments, and resorts); the invasion of exotic plants and animals; air and water pollution, mainly from agricultural activities including concentrated animal feed operations; and over-harvesting and poaching of species. Many of the Carolina DPS' spawning rivers, located in the Mid-Coastal Plain, originate in areas of marl. Waters draining calcareous, impervious surface materials such as marl are: (1) likely to be alkaline; (2) dominated by surface run-off; (3) have little groundwater connection; and, (4) are seasonally ephemeral.

Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002, Secor 2002). Secor (2002) estimates that 8,000 adult females were present in South Carolina during that same time-frame. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS. Currently, the Atlantic sturgeon spawning population in at least one river system within the Carolina DPS has been extirpated, with a potential extirpation in an additional system. The ASSRT estimated the remaining river populations within the DPS to have fewer than 300 spawning adults; this is thought to be a small fraction of historic population sizes (ASSRT 2007).

Threats

The Carolina DPS was listed as endangered under the ESA as a result of a combination of habitat curtailment and modification, overutilization (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

The modification and curtailment of Atlantic sturgeon habitat resulting from dams, dredging, and degraded water quality is contributing to the status of the Carolina DPS. Dams have curtailed Atlantic sturgeon spawning and juvenile developmental habitat by blocking over 60 percent of the historical sturgeon habitat upstream of the dams in the Cape Fear and Santee-Cooper River systems. Water quality (velocity, temperature, and dissolved oxygen (DO)) downstream of these dams, as well as on the Roanoke River, has been reduced, which modifies and curtails the extent of spawning and nursery habitat for the Carolina DPS. Dredging in spawning and nursery grounds modifies the quality of the habitat and is further curtailing the extent of available habitat in the Cape Fear and Cooper Rivers, where Atlantic sturgeon habitat has already been modified and curtailed by the presence of dams. Reductions in water quality from terrestrial activities have modified habitat utilized by the Carolina DPS. In the Pamlico and Neuse systems, nutrient-loading and seasonal anoxia are occurring, associated in part with concentrated animal feeding operations (CAFOs). Heavy industrial development and CAFOs have degraded water quality in the Cape Fear River. Water quality in the Waccamaw and Pee Dee rivers have been affected by industrialization and riverine sediment samples contain high levels of various toxins, including dioxins. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the Carolina DPS. Twenty interbasin water transfers in existence prior to 1993, averaging 66.5 million gallons per day (mgd), were authorized at their maximum levels without being subjected to an evaluation for certification by North Carolina Department of Environmental and Natural Resources or other resource agencies. Since the 1993 legislation requiring certificates for transfers, almost 170 mgd of interbasin water withdrawals have been authorized, with an additional 60 mgd pending certification. The removal of large amounts of water from the system will alter flows, temperature, and DO. Existing water allocation issues will likely be compounded by population growth and potentially, by climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient-loading, pollution inputs, and lower DO, all of which are current stressors to the Carolina DPS.

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast, from which they have never rebounded. Further, continued overutilization of Atlantic sturgeon as bycatch in commercial fisheries is an ongoing impact to the Carolina DPS. Little data exists on bycatch in the Southeast and high levels of bycatch underreporting are suspected. Further, total population abundance for the DPS is not available, and it is, therefore, not possible to calculate the percentage of the DPS subject to bycatch mortality based on the available bycatch mortality rates for individual fisheries. However, fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

As a wide-ranging anadromous species, Carolina DPS Atlantic sturgeon are subject to numerous Federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms have addressed impacts to Atlantic sturgeon through directed fisheries, there are currently no mechanisms in place to address the significant risk posed to Atlantic sturgeon from commercial bycatch. Though statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species, such as Atlantic sturgeon, and their habitat, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the Carolina DPS, even with existing controls on some pollution sources. Current regulatory regimes are not necessarily effective in controlling water allocation issues (e.g., no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution, etc.)

The recovery of Atlantic sturgeon along the Atlantic Coast, especially in areas where habitat is limited and water quality is severely degraded, will require improvements in the following areas: (1) elimination of barriers to spawning habitat either through dam removal, breaching, or installation of successful fish passage facilities; (2) operation of water control structures to provide appropriate flows, especially during spawning season; (3) imposition of dredging restrictions including seasonal moratoriums and avoidance of spawning/nursery habitat; and, (4) mitigation of water quality parameters that are restricting sturgeon use of a river (i.e., DO). Additional data regarding sturgeon use of riverine and estuarine environments is needed.

The concept of a viable population able to adapt to changing environmental conditions is critical to Atlantic sturgeon, and the low population numbers of every river population in the Carolina DPS put them in danger of extinction throughout their range; none of the populations are large or stable enough to provide with any level of certainty for continued existence of Atlantic sturgeon in this part of its range. Although the largest impact that caused the precipitous decline of the species has been curtailed (directed fishing), the population sizes within the Carolina DPS are at greatly reduced levels compared to historical population sizes. Small numbers of individuals

resulting from drastic reductions in populations, such as occurred with Atlantic sturgeon due to the commercial fishery, can remove the buffer against natural demographic and environmental variability provided by large populations (Berry, 1971; Shaffer, 1981; Soulé, 1980). Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon, and they continue to face a variety of other threats that contribute to their risk of extinction. While a long life-span also allows multiple opportunities to contribute to future generations, it also increases the timeframe over which exposure to the multitude of threats facing the Carolina DPS can occur.

The viability of the Carolina DPS depends on having multiple self-sustaining riverine spawning populations and maintaining suitable habitat to support the various life functions (spawning, feeding, growth) of Atlantic sturgeon populations. Because a DPS is a group of populations, the stability, viability, and persistence of individual populations affects the persistence and viability of the larger DPS. The loss of any population within a DPS will result in: (1) a long-term gap in the range of the DPS that is unlikely to be recolonized; (2) loss of reproducing individuals; (3) loss of genetic biodiversity; (4) potential loss of unique haplotypes; (5) potential loss of adaptive traits; and (6) reduction in total number. The loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (Secor and Waldman 1999). The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, the immigration into marine habitats to grow, and then the return of adults to natal rivers to spawn.

Summary of the Status of the Carolina DPS of Atlantic Sturgeon

In summary, the Carolina DPS is a small fraction of its historic population size. The ASSRT estimated there to be less than 300 spawning adults per year (total of both sexes) in each of the major river systems occupied by the DPS in which spawning still occurs. Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. While a long life-span allows multiple opportunities to contribute to future generations, this is hampered within the Carolina DPS by habitat alteration and bycatch. This DPS was severely depleted by past directed commercial fishing, and faces ongoing impacts and threats from habitat alteration or inaccessibility, bycatch, and the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch that have prevented river populations from rebounding and will prevent their recovery.

The presence of dams has resulted in the loss of over 60 percent of the historical sturgeon habitat on the Cape Fear River and in the Santee-Cooper system. Dams are contributing to the endangered status of the Carolina DPS by curtailing the extent of available spawning habitat and further modifying the remaining habitat downstream by affecting water quality parameters (such as depth, temperature, velocity, and DO) that are important to sturgeon. Dredging is also contributing to the status of the Carolina DPS by modifying Atlantic sturgeon spawning and nursery habitat. Habitat modifications through reductions in water quality are contributing to the status of the Carolina DPS due to nutrient-loading, seasonal anoxia, and contaminated sediments. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch is also a current threat to the Carolina DPS that is contributing to its status. Fisheries

known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may utilize multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning. While many of the threats to the Carolina DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch is currently not being addressed through existing mechanisms. Further, access to habitat and water quality continues to be a problem even with NMFS' authority under the Federal Power Act to recommend fish passage and existing controls on some pollution sources. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the Carolina DPS.

4.12 South Atlantic DPS of Atlantic sturgeon

The South Atlantic DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto Rivers (ACE) Basin southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida. The marine range of Atlantic sturgeon from the South Atlantic DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida.

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, and Satilla Rivers. We determined spawning was occurring if young-of-the-year (YOY) were observed, or mature adults were present, in freshwater portions of a system (Table 11). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. Historically, both the Broad-Coosawatchie and St. Marys Rivers were documented to have spawning populations at one time; there is also evidence that spawning may have occurred in the St. Johns River or one of its tributaries. However, the spawning population in the St. Marys River, as well as any historical spawning population present in the St. Johns, is believed to be extirpated, and the status of the spawning population in the Broad-Coosawatchie is unknown. Both the St. Marys and St. Johns Rivers are used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. The use of the Broad-Coosawatchie by sturgeon from other spawning populations is unknown at this time. The presence of historical and current spawning populations in the Ashepoo River has not been documented; however, this river may currently be used for nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems utilized by the South Atlantic DPS for specific life functions, such as spawning, nursery habitat, and foraging. However, fish from the South Atlantic DPS likely use other river systems than those listed here for their specific life functions.

Table 11: Major rivers, tributaries, and sounds within the range of the South Atlantic DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system

River/Estuary	Spawning Population	Data
ACE (Ashepoo, Combahee, and Edisto Rivers) Basin, SC; St. Helena Sound	Yes	1,331 YOY (1994-2001); gravid female and running ripe male in the Edisto (1997); 39 spawning adults (1998)
Broad-Coosawhatchie Rivers, SC; Port Royal Sound	Unknown	
Savannah River, SC/GA	Yes	22 YOY (1999-2006); running ripe male (1997)
Ogeechee River, GA	Yes	age-1 captures, but high inter-annual variability (1991-1998); 17 YOY (2003); 9 YOY (2004)
Altamaha River, GA	Yes	74 captured/308 estimated spawning adults (2004); 139 captured/378 estimated spawning adults (2005)
Satilla River, GA	Yes	4 YOY and spawning adults (1995-1996)
St. Marys River, GA/FL	Extirpated	
St. Johns River, FL	Extirpated	

The riverine spawning habitat of the South Atlantic DPS occurs within the South Atlantic Coastal Plain ecoregion (TNC 2002b), which includes fall-line sandhills, rolling longleaf pine uplands, wet pine flatwoods, isolated depression wetlands, small streams, large river systems, and estuaries. Other ecological systems in the ecoregion include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. Other ecological systems in the ecoregion include maritime forests on barrier islands, pitcher plant seepage bogs and Altamaha grit (sandstone) outcrops. The primary threats to biological diversity in the South Atlantic Coastal Plain listed by TNC are intensive silvicultural practices, including conversion of natural forests to highly managed pine monocultures and the clear-cutting of bottomland hardwood forests. Changes in water quality and quantity, caused by hydrologic alterations (impoundments, groundwater withdrawal, and ditching), and point and nonpoint pollution, are threatening the aquatic systems. Development is a growing threat, especially in coastal areas. Agricultural conversion, fire regime alteration, and the introduction of nonnative species are additional threats to the ecoregion's diversity. The South Atlantic DPS' spawning rivers, located in the South Atlantic Coastal Plain, are primarily of two types: brownwater (with headwaters north of the Fall Line, silt-laden) and blackwater (with headwaters in the coastal plain, stained by tannic acids).

Secor (2002) estimates that 8,000 adult females were present in South Carolina prior to 1890. Prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery in Georgia. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in the state prior to 1890. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the South Atlantic DPS. Currently, the Atlantic sturgeon spawning population in at least two river systems within the South Atlantic DPS has been extirpated. The Altamaha River population of Atlantic sturgeon, with an estimated 343 adults spawning annually, is believed to be the largest population in the Southeast, yet is estimated to be only 6 percent of its historical population size. The ASSRT estimated the abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, to be less than 1 percent of what they were historically (ASSRT 2007).

Threats

The South Atlantic DPS was listed as endangered under the ESA as a result of a combination of habitat curtailment and modification, overutilization (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

The modification and curtailment of Atlantic sturgeon habitat resulting from dredging and degraded water quality is contributing to the status of the South Atlantic DPS. Dredging is a present threat to the South Atlantic DPS and is contributing to their status by modifying the quality and availability of Atlantic sturgeon habitat. Maintenance dredging is currently modifying Atlantic sturgeon nursery habitat in the Savannah River and modeling indicates that the proposed deepening of the navigation channel will result in reduced DO and upriver movement of the salt wedge, curtailing spawning habitat. Dredging is also modifying nursery and foraging habitat in the St. Johns River. Reductions in water quality from terrestrial activities have modified habitat utilized by the South Atlantic DPS. Low DO is modifying sturgeon habitat in the Savannah due to dredging, and non-point source inputs are causing low DO in the Ogeechee River and in the St. Marys River, which completely eliminates juvenile nursery habitat in summer. Low DO has also been observed in the St. Johns River in the summer. Sturgeon are more sensitive to low DO and the negative (metabolic, growth, and feeding) effects caused by low DO increase when water temperatures are concurrently high, as they are within the range of the South Atlantic DPS. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the South Atlantic DPS. Large withdrawals of over 240 million gallons per day mgd of water occur in the Savannah River for power generation and municipal uses. However, users withdrawing less than 100,000 gallons per day (gpd) are not required to get permits, so actual water withdrawals from the Savannah and other rivers within the range of the South Atlantic DPS are likely much higher. The removal of large amounts of water from the system will alter flows, temperature, and DO. Water shortages and “water wars” are already occurring in the rivers occupied by the South Atlantic DPS and will likely be compounded in the future by population growth and potentially by climate change. Climate change is also predicted to elevate water

temperatures and exacerbate nutrient-loading, pollution inputs, and lower DO, all of which are current stressors to the South Atlantic DPS.

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast, from which they have never rebounded. Further, continued overutilization of Atlantic sturgeon as bycatch in commercial fisheries is an ongoing impact to the South Atlantic DPS. The loss of large subadults and adults as a result of bycatch impacts Atlantic sturgeon populations because they are a long-lived species, have an older age at maturity, have lower maximum fecundity values, and a large percentage of egg production occurs later in life. Little data exists on bycatch in the Southeast and high levels of bycatch underreporting are suspected. Further, a total population abundance for the DPS is not available, and it is therefore not possible to calculate the percentage of the DPS subject to bycatch mortality based on the available bycatch mortality rates for individual fisheries. However, fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

As a wide-ranging anadromous species, Atlantic sturgeon are subject to numerous Federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms have addressed impacts to Atlantic sturgeon through directed fisheries, there are currently no mechanisms in place to address the significant risk posed to Atlantic sturgeon from commercial bycatch. Though statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species, such as Atlantic sturgeon, and their habitat, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the South Atlantic DPS, even with existing controls on some pollution sources. Current regulatory regimes are not necessarily effective in controlling water allocation issues (e.g., no permit requirements for water withdrawals under 100,000 gpd in Georgia, no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution.)

The recovery of Atlantic sturgeon along the Atlantic Coast, especially in areas where habitat is limited and water quality is severely degraded, will require improvements in the following areas: (1) elimination of barriers to spawning habitat either through dam removal, breaching, or installation of successful fish passage facilities; (2) operation of water control structures to provide appropriate flows, especially during spawning season; (3) imposition of dredging restrictions including seasonal moratoriums and avoidance of spawning/nursery habitat; and, (4) mitigation of water quality parameters that are restricting sturgeon use of a river (i.e., DO). Additional data regarding sturgeon use of riverine and estuarine environments is needed.

A viable population able to adapt to changing environmental conditions is critical to Atlantic sturgeon, and the low population numbers of every river population in the South Atlantic DPS put them in danger of extinction throughout their range. None of the populations are large or stable enough to provide with any level of certainty for continued existence of Atlantic sturgeon in this part of its range. Although the largest impact that caused the precipitous decline of the species has been curtailed (directed fishing), the population sizes within the South Atlantic DPS have remained relatively constant at greatly reduced levels for 100 years. Small numbers of individuals resulting from drastic reductions in populations, such as occurred with Atlantic sturgeon due to the commercial fishery, can remove the buffer against natural demographic and environmental variability provided by large populations (Berry, 1971; Shaffer, 1981; Soulé, 1980). Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon, and they continue to face a variety of other threats that contribute to their risk of extinction. While a long life-span also allows multiple opportunities to contribute to future generations, it also increases the timeframe over which exposure to the multitude of threats facing the South Atlantic DPS can occur.

Summary of the Status of the South Atlantic DPS of Atlantic Sturgeon

The South Atlantic DPS is estimated to number a fraction of its historical abundance. . There are an estimated 343 spawning adults per year in the Altamaha and less than 300 spawning adults per year (total of both sexes) in each of the other major river systems occupied by the DPS in which spawning still occurs, whose freshwater range occurs in the watersheds (including all rivers and tributaries) of the ACE Basin southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida. Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. While a long life-span also allows multiple opportunities to contribute to future generations, this is hampered within the South Atlantic DPS by habitat alteration, bycatch, and from the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch.

Dredging is contributing to the status of the South Atlantic DPS by modifying spawning, nursery, and foraging habitat. Habitat modifications through reductions in water quality are also contributing to the status of the South Atlantic DPS through reductions in DO, particularly during times of high water temperatures, which increase the detrimental effects on Atlantic sturgeon habitat. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch is also a current impact to the South Atlantic DPS that is contributing to its status. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may utilize multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning. While many of the threats to the South Atlantic DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch is currently not being addressed through existing mechanisms. Further, access to habitat and water

quality continues to be a problem even with NMFS' authority under the Federal Power Act to recommend fish passage and existing controls on some pollution sources. There is a lack of regulation for some large water withdrawals, which threatens sturgeon habitat. Current regulatory regimes do not require a permit for water withdrawals under 100,000 gpd in Georgia and there are no restrictions on interbasin water transfers in South Carolina. Existing water allocation issues will likely be compounded by population growth, drought, and potentially climate change. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the South Atlantic DPS.

4.13 Summary of Available Information on Use of Action Area by Listed Species

4.13.1 *Sea turtles*

Sea turtles are seasonally present in Delaware Bay from May to early November each year, with the highest number of individuals present from June to October. Sea turtles occur as far upstream as Artificial Island, but are unlikely to be present in reaches further upstream; as such sea turtles are only present in Reaches D and E.

One of the main factors influencing sea turtle presence in northern waters is seasonal temperature patterns (Ruben and Morreale 1999). Temperature is correlated with the time of year, with the warmer waters in the late spring, summer, and early fall being the most suitable for cold-blooded sea turtles. Sea turtles are most likely to occur in the action area between June and October when water temperatures are above 11°C and depending on seasonal weather patterns, could be present in May and early November. Sea turtles have been documented in the action area by the CETAP aerial and boat surveys as well as by surveys conducted by NMFS Northeast Science Center and fisheries observers. Additionally, satellite tracked sea turtles have been documented in the action area (seaturtle.org tracking database). The majority of sea turtle observations have been of loggerhead sea turtles, although all four species of sea turtles have been recorded in the area.

To some extent, water depth also dictates the number of sea turtles occurring in a particular area. The only areas to be dredged have water depths of less than 45 feet. Satellite tracking studies of sea turtles in the Northeast found that foraging turtles mainly occurred in areas where the water depth was between approximately 16 and 49 ft (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). The areas to be dredged and the depths preferred by sea turtles do overlap, suggesting that if suitable forage was present, loggerheads and Kemp's ridleys may be foraging in the channel areas where dredging will occur. As there are no SAV beds in any of the channel areas where dredging will occur, green sea turtles are not likely to use the areas to be dredged for foraging.

4.13.2 *Shortnose Sturgeon*

Shortnose sturgeon occur in the Delaware River from the lower bay upstream to at least Lambertville, New Jersey (rkm 238). Tagging studies by O'Herron *et al.* (1993) found that the most heavily used portion of the river appears to be between rkm 190 below Burlington Island and rkm 220 at the Trenton Rapids. Hastings *et al.* (1987) used Floy T-anchor tags in a tag-and-recapture experiment from 1981 to 1984 to estimate the size of the Delaware River population in

the Trenton to Florence reach. Population sizes by three estimation procedures ranged from 6,408 to 14,080 adult sturgeon. These estimates compare favorably with those based upon similar methods in similar river systems. This is the best available information on population size, but because the recruitment and migration rates between the population segment studied and the total population in the river are unknown, model assumptions may have been violated.

In the Delaware River, movement to the spawning grounds occurs in early spring, typically in late March¹¹, with spawning occurring through the end of April. Movement to the spawning areas is triggered in part by water temperature and fish typically arrive at the spawning locations when water temperatures are between 8-9°C with most spawning occurring when water temperatures are between 10 and 15°C. Studies conducted between 2007 and 2013 (ERC 2008; DENREC 2015) indicate that shortnose sturgeon utilize at least a 22 km reach of the non-tidal river from Trenton rapids to the Lambertville rapids for spawning. Spawning activity is likely greatest in the rapids and high velocity run areas, such as those below the Lambertville wing dam and Scudders Falls. However, some spawning activity may occur throughout the reach, since much of it features clean cobble/gravel substrate and at least moderate current velocities suitable for Shortnose Sturgeon spawning. The spawning area is well upstream of the Philadelphia to Trenton channel. The capture of early life stages (eggs and larvae) in this region in the spring of 2008 confirms that this area of the river is used for spawning and as a nursery area (ERC 2009). During the spawning period, males remain on the spawning grounds for approximately a week while females only stay for a few days (O'Herron and Hastings 1985). After spawning, which typically ceases by the time water temperatures reach 15°C (although sturgeon have been reported on the spawning grounds at water temperatures as high as 18°C), shortnose sturgeon move rapidly downstream to the Philadelphia area.

Shortnose sturgeon eggs generally hatch after approximately 9-12 days (Buckley and Kynard 1981). 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. Larvae are expected to begin swimming downstream at 9-14 days old (Richmond and Kynard 1995). Larvae are expected to be less than 20mm TL at this time (Richmond and Kynard 1995). This initial downstream migration generally lasts two to three days (Richmond and Kynard 1995). Studies (Kynard and Horgan 2002) suggest that larvae move approximately 7.5km/day during this initial 2 to 3 day migration. Laboratory studies indicate that young sturgeon move downstream in a 2-step migration: the initial 2-3 day migration followed by a residency period of the Young of the Year (YOY), then a resumption of migration by yearlings in the second summer of life (Buckley and Kynard 1981).

In other river systems, older juveniles (3-10 years old) occur in the saltwater/freshwater interface (NMFS 1998). In these systems, juveniles moved back and forth in the low salinity portion of the

¹¹ Based on US Geological Survey (USGS) water temperature data for the Delaware River at the Trenton gage (USGS gage 01463500; the site closest to the Scudders Falls area), for the period 2003-2009, water temperature reached 8°C sometime between March 26 (2006) and April 21 (2007), with temperatures typically reaching 8°C in the last few days of March. During this period, mean water temperatures at Trenton reached 10°C between March 28 (2004) and April 22 (2007) and 15°C between April 15 (2006) and April 21 (2003). There is typically a three to four week period with mean daily temperatures between 8 and 15°C.

salt wedge during summer. In the Delaware River the oligohaline/fresh interface can range from as far south as Wilmington, Delaware, north to Philadelphia, Pennsylvania, depending upon meteorological conditions such as excessive rainfall or drought. As a result, it is possible that in the Delaware River, juveniles could range from Artificial Island (rkm87) to the Schuylkill River (rkm 148) (O'Herron 2000, pers. comm.). Acoustic tracking of tagged juveniles indicates that juveniles are likely overwintering in the lower Delaware River from Philadelphia to below Artificial Island (ERC 2007). The distribution of juveniles in the river is likely highly influenced by flow and salinity. In years of high flow (for example, due to excessive rains or a significant spring runoff), the salt wedge will be pushed seaward and the low salinity reaches preferred by juveniles will extend further downriver. In these years, shortnose sturgeon juveniles are likely to be found further downstream in the summer months. In years of low flow, the salt wedge will be higher in the river and in these years juveniles are likely to be concentrated further upstream.

O'Herron believes that if juveniles are present within this range they would likely aggregate closer to the downstream boundary in the winter when freshwater input is normally greater (O'Herron 2000, pers. comm.). Research in other river systems indicates that juveniles are typically found over silt and sand/mud substrates in deep water of 10-20m. Juvenile sturgeon primarily feed in 10 to 20 meter deep river channels, over sand-mud or gravel-mud bottoms (Pottle and Dadswell 1979). However, little is known about the specific feeding habits of juvenile shortnose sturgeon in the Delaware River.

As noted above, after spawning, adult shortnose sturgeon migrate rapidly downstream to the Philadelphia area (RM 100). After adult sturgeon migrate to the area around Philadelphia, many adults return upriver to between rkm 204 and 216 within a few weeks, while others gradually move to the same area over the course of the summer (O'Herron 1993). By the time water temperatures have reached 10°C, typically by mid-November¹², most adult sturgeon have returned to the overwintering grounds around Duck Island and Newbold Island. These patterns are generally supported by the movement of radio-tagged fish in the region between rkm 201 and rkm 238 as presented by Brundage (1986). Based on water temperature data collected at the USGS gage at Philadelphia, in general, shortnose sturgeon are expected to be at the overwintering grounds between early November and mid-April. A large number of adult shortnose sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between rkm 190 and 211. The areas around Duck Island and Newbold Island seem to be regions of intense overwintering concentrations. However, unlike sturgeon in other river systems, there is evidence that some shortnose sturgeon in the Delaware do not remain stationary during overwintering periods, appearing at the surface and even breaching through the skim ice (O'Herron 1993). Due to the relatively active nature of some shortnose sturgeon, the use of the river during the winter is difficult to predict. However, O'Herron *et al.* (1993) found that the typical overwintering movements are fairly localized and sturgeon appear to remain within 2 river kilometers of the aggregation site (O'Herron and Able 1986). Investigations with video equipment by the USACE in March 2005 (Versar 2006) documented two sturgeon of unknown

¹² Based on information from the USGS gage at Philadelphia (01467200) during the 2003-2008 time period, mean water temperatures reached 10°C between October 29 (2005 and 2006) and November 14 (2003). In the spring, mean water temperature reached 10°C between April 2 (2006) and April 21 (2009).

species at Marcus Hook and 1 sturgeon of unknown species at Tinicum. Gillnetting in these same areas caught only one Atlantic sturgeon and no shortnose sturgeon. Video surveys of the known overwintering area near Newbold documented 61 shortnose sturgeon in approximately 1/3 of the survey effort. This study supports the conclusion that the vast majority of adult shortnose sturgeon overwinter near Duck and Newbold Island but that a limited number of shortnose sturgeon occur in other downstream areas, including Marcus Hook, during the winter months. Brundage and O'Herron (2014a) carried out a relocation trawl pilot study in the Marcus Hook Anchorage (rkm 127-139) from January 25-March 7, 2014. Captured fish were relocated to the Ft. Mifflin (rkm 147), Torresdale (rkm 176), and Burlington (rkm 193) ranges of the Delaware River. While trawling, they collected 67 shortnose sturgeon (48 adults, 19 juveniles), indicating that the Marcus Hook area is used by adult as well as juvenile shortnose sturgeon. Overwintering juveniles are expected to occur on the freshwater side of the oligohaline/fresh water interface (O'Herron 1990). In the Delaware River, during the winter months the oligohaline/freshwater interface occurs in the area between Wilmington, Delaware and Marcus Hook/Philadelphia, Pennsylvania area (O'Herron 1990).

Shortnose sturgeon appear to be strictly benthic feeders (Dadswell 1984). Adults eat mollusks, insects, crustaceans and small fish. Juveniles eat crustaceans and insects. The Asiatic river clam (*Corbicula manilensis*) is a major component of the benthos in the tidal Delaware River; *corbicula* have been documented in the diet of shortnose sturgeon in the Delaware River and other estuaries (Brundage, pers. comm. 2011). *Corbicula* is widely distributed at all depths in the upper tidal Delaware River, but it is considerably more numerous in the shallows on both sides of the river than in the navigation channels. Foraging is heaviest immediately after spawning in the spring and during the summer and fall, and lighter in the winter.

Historically, sturgeon were relatively rare below Philadelphia due to poor water quality. Since the 1990s, the water quality in the Philadelphia area has improved leading to an increased use of the lower river by shortnose sturgeon. Few studies have been conducted to document the use of the river below Philadelphia by sturgeon. Brundage and Meadows (1982) have reported incidental captures in commercial gillnets in the lower Delaware. During a study focusing on Atlantic sturgeon, Shirey *et al.* (1999) captured 9 shortnose sturgeon in 1998. During the June through September study period, Atlantic and shortnose sturgeon were found to use the area on the west side of the shipping channel between Deep Water Point, New Jersey and the Delaware-Pennsylvania line. The most frequently utilized areas within this section were off the northern and southern ends of Cherry Island Flats in the vicinity of the Marcus Hook Bar. A total of 25 shortnose sturgeon have been captured by Shirey in this region of the river from 1992 - 2004, with capture rates ranging from 0-10 fish per year (Shirey 2006). Shortnose sturgeon have also been documented at the trash racks of the Salem nuclear power plant in Salem, New Jersey at Artificial Island.

In May 2005, a one-year survey for juvenile sturgeon in the Delaware River in the vicinity of the proposed Crown Landing LNG project was initiated. The objective of the survey was to obtain information on the occurrence and distribution of juvenile shortnose and Atlantic sturgeon near the proposed project site to be located near rkm 126, approximately 32 kilometers south of Philadelphia. Sampling for juvenile sturgeon was performed using trammel nets and small mesh

gill nets. The nets were set at three stations, one located adjacent to the project site, one at the upstream end of the Marcus Hook anchorage (approximately 4 kilometers upstream of the project site, at rkm 130), and one near the upstream end of the Cherry Island Flats (at rkm 119; approximately 6 kilometers downstream of the site). Nets were set within three depth ranges at each station: shallow (<10 feet at MLW), intermediate (10-20 feet at MLW) and deep (20-30+ feet at MLW). Each station/depth zone was sampled once per month. Nets were set for at least 4 hours when water temperatures were less than 27°C and limited to 2 hours when water temperature was greater than 27°C. The sampling from April through August 2005 yielded 3,014 specimens of 22 species, including 3 juvenile shortnose sturgeon. Juvenile shortnose sturgeon were collected during the June, July and August, one fish in each of the sampling events. Two of the shortnose sturgeon were collected at rkm 126 and one was taken at the downstream sampling station at rkm 119. Total length ranged from 311-367mm. During the September – December sampling, one juvenile shortnose sturgeon was caught in September at rkm 126 and one in November at the same location. One adult shortnose sturgeon was captured in October at rkm 119. All of the shortnose sturgeon were collected in deep water sets (greater than 20 feet). These depths are consistent with the preferred depths for foraging shortnose sturgeon juveniles reported in the literature (NMFS 1998). The capture of an adult in the Cherry Island Flats area (rkm 119) is consistent with the capture location of several adult sturgeon reported by Shirey *et al.* 1999 and Shirey 2006.

Brundage compiled a report presenting an analysis of telemetry data from receivers located at Torresdale rkm 150, Tinicum rkm 138, Bellevue rkm 117 and New Castle rkm 93 during April through December 2003. The objective of the study was to provide information on the occurrence and movements of shortnose sturgeon in the general vicinity of the proposed Crown Landing LNG facility. A total of 60 shortnose sturgeon had been tagged with ultrasonic transmitters: 30 in fall 2002, 13 in early summer 2003 and 13 in fall 2003. All tagged fish were adults tagged after collection in gill nets in the upper tidal Delaware River, between rkm 202-212. Of the 60 tagged sturgeon, 39 (65%) were recorded at Torresdale, 22 (36.7%) were recorded at Tinicum, 16 (26.7%) at Bellevue and 18 (30%) at New Castle. The number of tagged sturgeon recorded at each location varied with date of tagging. Of the 30 sturgeon tagged in fall 2002, 26 were recorded at Torresdale, 17 at Tinicum, 11 at Bellevue and 13 at New Castle. Only two of the 13 tagged in fall 2003 were recorded, both at Torresdale only. Brundage concludes that seasonal movement patterns and time available for dispersion likely account for this variation, particularly for the fish tagged in fall 2003. Eleven of the 30 shortnose sturgeon tagged in fall 2002 and 5 of the 17 fish tagged in summer 2003 were recorded at all four locations. Some of the fish evidenced rapid movements from one location sequentially to the next in upstream and/or downstream direction. These periods of rapid sequential movement tended to occur in the spring and fall, and were probably associated with movement to summer foraging and overwintering grounds, respectively. As a group, the shortnose sturgeon tagged in summer 2003 occurred a high percentage of time within the range of the Torresdale receiver. The report concludes that the metrics indicate that the Torresdale Range of the Delaware River is utilized by adult shortnose sturgeon more frequently and for greater durations than the other three locations. Of the other locations, the Tinicum Range appears to be the most utilized region. At all ranges, shortnose were detected throughout the study period, with most shortnose sturgeon detected in the project area between April and October. The report indicates that most adult shortnose

sturgeon used the Torresdale to New Castle area as a short-term migratory route rather than a long-term concentration or foraging area. Adult sturgeon in this region of the river are highly mobile, and as noted above, likely using the area as a migration route.

As evidenced by the Crown Landing study, juvenile shortnose sturgeon have been documented between rkm 130-119 from June – November. Due to the limited geographic scope of this study, it is difficult to use these results to predict the occurrence of juvenile shortnose sturgeon throughout the action area.

During Brundage and O’Herron’s (2014a) trawling and relocation study, 19 juvenile shortnose sturgeon were captured in the Marcus Hook area between February 25 and March 7. Therefore, juvenile shortnose sturgeon may be in this reach of the river year-round.

In 2005, USACE conducted investigations to determine the use of the Marcus Hook region by sturgeon. Surveys for the presence of Atlantic and shortnose sturgeon were conducted between March 4 and March 25, 2005 primarily using a Video Ray[®] Explorer submersible remotely operated vehicle (ROV). The Video Ray[®] was attached to a 1.0 x 1.0 x 1.5 meter aluminum sled which was towed over channel bottom habitats behind a 25-foot research boat. All images captured by the underwater camera were transmitted through the unit’s electronic tether and recorded on video cassettes. A total of 43 hours of bottom video were collected on 14 separate survey days. Twelve days of survey work were conducted at the Marcus Hook, Eddystone, Chester, and Tinicum ranges, while two separate days of survey work were conducted up river near Trenton, New Jersey, at an area known to have an overwintering population of shortnose sturgeon.

The sled was generally towed on the bottom parallel to the centerline of the channel and into the current at 0.8 knots. Tow track logs were maintained throughout the survey and any fish seen on the ROV monitor was noted. Boat position during each video tow was recorded every five minutes with the vessel’s Furuno GPS. The Sony digital recorder recorded a time stamp that could be matched with the geographic coordinates taken from the on-board GPS. Digital tapes were reviewed in a darkened laboratory at normal or slow speed using a high quality 28-inch television screen as a monitor. When a fish image was observed the tape was slowed and advanced frame by frame (30 images per second were recorded by the system). The time stamp where an individual fish was observed was recorded by the technician. Each fish was identified to the lowest practical taxon (usually species) and counted. A staff fishery biologist reviewed questionable images and species identifications. Distances traveled by the sled between time stamps were calculated based on the GPS coordinates recorded in the field during each tow. Total fish counts between the recorded coordinates within a particular tow were converted to observed numbers per 100 meters of tow track.

Limited 25-foot otter trawling and gillnet sets were conducted initially to provide density data, and later to provide ground truth information on the fish species seen in the video recording. Large boulders and other snags that tore the net and hung up the vessel early on in the study prompted abandoning this effort for safety reasons given the high degree of tanker traffic in the lower Delaware River. The trawl net was a 7.6-m (25-foot) experimental semi-balloon otter trawl

with 44.5-mm stretch mesh body fitted with a 3.2-mm stretch mesh liner in the cod end. Otter trawls were generally conducted for five minutes unless a snag or tanker traffic caused a reduction in tow time. Experimental gillnets were periodically deployed throughout the survey period in the Marcus Hook area. One experimental gillnet was 91.4-m in length and 3-m deep and was composed of six 15.2-m panels of varying mesh size. Of the six panels in each net, two panels were 50.8-mm stretch mesh, 2 panels were 101.6-mm stretch mesh and 2 panels were 152.4-mm stretch mesh. Another gillnet was 100 m in length and consisted of four 25 x 2-m panels of 2.5-10.2-cm stretched monofilament mesh in 2.5 cm increments. Gill nets were generally set an hour before slack high or low water and allowed to fish for two hours as the nets had to be retrieved before maximum currents were reached.

Turbidity in the Marcus Hook region of the Delaware River limited visibility to about 18 inches in front of the camera. However, despite the reduced visibility, several different fish species were recorded by the system including sturgeon. In general, fish that encountered the sled between the leading edge of the sled runners were relatively easy to distinguish. The major fish species seen in the video images were confirmed by the trawl and gillnet samples. In the Marcus Hook project area, a total of 39 survey miles of bottom habitat were recorded in twelve separate survey days. Eight different species were observed on the tapes from a total of 411 fish encountered by the camera. White perch, unidentified catfish, and unidentified shiner were the most common taxa observed. Three unidentified sturgeon were seen on the tapes, two in the Marcus Hook Range, and one in the Tinicum Range. Although it could not be determined if these sturgeon were Atlantic or shortnose, gillnetting in the Marcus Hook anchorage produced one juvenile Atlantic sturgeon that was 396 mm in total length, 342 mm in fork length, and weighed 250 g.

Water clarity in the Trenton survey area was much greater (about 6 feet ahead of the camera) and large numbers of shortnose sturgeon were seen in the video recordings. In a total of 7.9 survey miles completed in two separate days of bottom imaging, 61 shortnose sturgeons were observed. To provide a comparative measure of project area density (where visibility was limited) to up river densities (where visibility was greater), each of the 61 sturgeon images were classified as to whether the individual fish was observed between the sled runners or whether they were seen ahead of the sled. Real time play backs of video recordings in the upriver sites indicated that the sturgeon did not react to the approaching sled until the cross bar directly in front of the camera was nearly upon it. Thirty of the 61 upstream sturgeon images were captured when the individual fish was between the runners. Using this criterion, approximately 10 times more sturgeon were encountered in the upriver area relative to the project site near Marcus Hook where three sturgeons were observed. Using the number of sturgeon observed per 100 meters of bottom surveyed, the relative sturgeon density in the project area was several orders of magnitude less than those observed in the Trenton area. As calculated in the report, the relative density of unidentified sturgeon in the Marcus Hook area was 0.005 fish per 100 meters while the densities of shortnose sturgeon between the sled runners in the upriver area was 0.235 fish per 100 meters.

The results of the video sled survey in the Marcus Hook project area confirmed that sturgeons are using the area in the winter months. However, sturgeon relative densities in the project area were much lower than those observed near Trenton, New Jersey, even when the upriver counts were adjusted for the higher visibility (i.e., between runner sturgeon counts). The sturgeon seen

near Trenton were very much concentrated in several large aggregations, which were surveyed in multiple passes on the two sampling dates devoted to this area. The lack of avoidance of the approaching sled seen in the upriver video recordings where water clarity was good suggests that little to no avoidance of the sled occurred in the low visibility downriver project area. Video surveys in the downriver project area did not encounter large aggregations of sturgeon as was observed in the upstream survey area despite having five times more sampling effort than the upstream area. This suggests that sturgeon that do occur in the Marcus Hook area during the winter are more dispersed and that the overall number of shortnose sturgeon occurring in this area in the winter months is low.

However, results from the relocation trawl pilot study carried out in 2014 indicate that adult and juvenile shortnose sturgeon are present in the Marcus Hook area during the winter in larger numbers than previously predicted. In less than 8 hours of trawling, 67 shortnose sturgeon were collected. Tagged shortnose sturgeon were also detected in the Marcus Hook area during a sound deterrent test carried out from March 21 – May 7. Shortnose sturgeon present at Marcus Hook during the winter do appear to be more active than shortnose sturgeon documented at the upriver overwintering sites; therefore, there could have been greater avoidance behavior at Marcus Hook which could account for the lower detection on the video. It is also possible that the number of shortnose sturgeon at Marcus Hook varies annually. The time of year that the video survey was carried out (March 4-March 25) is similar to the time of year the trawl survey took place (February 25 to March 7); therefore, it does not appear that the difference is a result of the timing of the survey. Based on this new information, we expect juvenile and adult shortnose sturgeon in the Marcus Hook area during the winter months; however, we do not expect them to occur in dense, sedentary aggregations as is seen in the upriver overwintering sites.

The results of tracking studies indicate that during the winter months juvenile and adult shortnose sturgeon are more well distributed in the Delaware River than previously thought. ERC (2007) tracked four shortnose sturgeon; three of the shortnose sturgeon were tracked through the winter (one shortnose was only tracked from May – August 2006). Shortnose sturgeon 171 was located in the Baker Range in early January (rkm 83), and moved upriver to the Deepwater Point Range (rkm 105) in mid-January where it remained until it moved rapidly to Marcus Hook (rkm 130) on March 12. Shortnose sturgeon 2950 was tracked through February 2, 2007. In December the fish was located in the Bellevue Range (rkm 120). Between January 29 and February 2, the fish moved between Marcus Hook (rkm 125) and Cherry Island (rkm 116). Shortnose sturgeon 2953 also exhibited significant movement during the winter months, moving between rkm 123 and 163 from mid-December through mid-March. Tracking of adult and juvenile shortnose sturgeon captured near Marcus Hook (rkm 127-139) and relocated to one of three areas (rkm 147, 176 and 193) demonstrated extensive movements during the winter period.

Although they have been documented in waters with salinities as high as 31 parts per thousand (ppt), shortnose sturgeon are typically concentrated in areas with salinity levels of less than 3 ppt (Dadswell *et al.* 1984). Jenkins *et al.* (1993) demonstrated in lab studies that 76 day old shortnose sturgeon experienced 100% mortality in salinity greater than 14 ppt. One year old shortnose sturgeon were able to tolerate salinity levels as high as 20 ppt for up to 18 hours but experienced 100% mortality at salinity levels of 30 ppt. A salinity of 9 ppt appeared to be a

threshold at which significant mortalities began to occur, especially among the youngest fish (Jenkins *et al.* 1993). The distribution of salinity in the Delaware estuary exhibits significant variability on both spatial and temporal scales, and at any given time reflects the opposing influences of freshwater inflow from tributaries versus saltwater inflow from the Atlantic Ocean. The estuary can be divided into four longitudinal salinity zones. Starting at the downstream end, the mouth of the Bay to rkm 55 is considered polyhaline (18-30ppt), rkm 55-71 is mesohaline (5-18ppt), rkm 71-127 is oligohaline (0.5-5ppt), and Marcus Hook (rkm 127) to Trenton is considered Fresh (0.0-0.5ppt). Based on this information and the known tolerances and preferences of shortnose sturgeon to salinity, shortnose sturgeon are most likely to occur upstream of rkm 70 where salinity is typically less than 5ppt. As tolerance to salinity increases with age and size, large juveniles and adults are likely to be present through the mesohaline area extending to rkm 55. Due to the typical high salinities experienced in the polyhaline zone (below rkm 55), shortnose sturgeon are likely to be rare in this reach of the river; this area covers Reach E.

Expected Seasonal Distribution of Shortnose Sturgeon in Reaches AA - E

As described in the “Description of the Action” section above, dredging will occur in six river reaches (see Table 1). The discussion below will summarize the likely seasonal distribution of shortnose sturgeon in these river reaches. Based on the best available information, eggs and larvae are not likely to be in the action area. Due to the benthic, adhesive nature of the eggs, they only occur in the immediate vicinity of the spawning area, located at least 48 kilometers upstream of the action area. Larvae are also limited to an area close to the spawning grounds, and therefore, not likely to occur in the action area. Distribution of adult and juvenile shortnose sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity.

Both adult and juvenile shortnose sturgeon occur in Reach AA (rkm 164 – 156) any time water temperatures are greater than 10°C (the trigger for movement to overwintering areas); these temperatures are typically experienced between early April and mid-late November¹³. Shortnose sturgeon in this reach are likely to be using it for migration and for opportunistic foraging. This reach of the river is not known to be a concentration area for any life stage of shortnose sturgeon. As evidenced by tracking (ERC 2007; Brundage and O’Herron 2014a), some juvenile and adult shortnose sturgeon and juvenile Atlantic sturgeon are also likely to move through Reach AA during the winter. Therefore, we expect that juvenile and adult shortnose sturgeon will occur in Reach AA year-round. Similarly, Reach A (rkm 156-137) is also likely to be used by migrating shortnose sturgeon and for opportunistic foraging. This reach of the river includes the Torresdale Range (rkm 150), an area which the 2003-2004 telemetry study noted above suggests may be a relatively high use area for shortnose sturgeon in the April – October time frame. The number of shortnose sturgeon utilizing the Torresdale area suggests that conditions in Torresdale may support a shortnose sturgeon foraging or resting area; however, the tracking data indicates that shortnose sturgeon in this reach are highly mobile. We expect juvenile and adult shortnose sturgeon in Reach A year round. Reach B (rkm 137-108) encompasses the Cherry Island Flats

¹³ For example, in 2004 temperatures reached 10°C on April 2 and dropped to 10°C on November 13. In 2005 temperatures were above 10°C between April 11 and November 23.

and Marcus Hook Bar areas. The capture of multiple shortnose sturgeon in this reach during the summer months (Shirey 1999 and 2006) indicates that shortnose sturgeon are likely to be foraging here in this summer and that it may serve as a summer concentration area. Evidence also suggests that at least some shortnose sturgeon may overwinter near Marcus Hook, or that at least that some shortnose sturgeon are present in this area during the winter (Versar 2006; ERC 2012; Brundage and O’Herron 2009; Brundage and O’Herron 2014a). Adult and juvenile shortnose sturgeon were collected in a trawl operating in the Marcus Hook, Eddystone, Chester and Tinicum ranges from February 25 – March 7, 2015. As such, shortnose sturgeon could be present in Reach B year round, with the highest numbers present when water temperatures are above 10°C between April and November.

Reach C encompasses the area from rkm 108-89 and includes the New Castle range where the 2003-2004 telemetry studies indicated was an area frequented by shortnose sturgeon. This area also includes the outlet of the Chesapeake-Delaware canal which has been documented to be used by shortnose sturgeon moving between the upper Chesapeake Bay and the Delaware River. Based on the best available information, shortnose may be present in this reach of the river year round.

Reach D includes rkm 89-66 and includes the area near Artificial Island. Between 1977 and 2013, 25 shortnose sturgeon were recorded at the Salem Nuclear Generating Facility intakes. Shortnose sturgeon have been removed from the intakes in all months except August and September. Shortnose sturgeon at least occasionally occur in Reach D; however, the low number of documented occurrences in this reach combined with the higher salinity levels, make this reach less likely to be used than other upstream reaches.

Reach E includes rkm 66-8. Based on the best available information, including the high salinity levels in this reach, the presence of shortnose sturgeon is expected to be rare; however, occasional shortnose sturgeon may occur in this reach between late April and mid-November.

4.13.3 Atlantic sturgeon in the Action Area

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). 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 1830s 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 between rkm 77 and 130 (Delaware City, DE to Chester City, PA). Based on tagging and tracking studies carried out from 2009-2011, Breece (2011) reports likely spawning locations are at rkm 120-150 and rkm 170-190. The shift from historical spawning sites is thought to be at least partially related to changes in the location of the

salt line over time. Hard bottom habitat believed to be appropriate for sturgeon spawning (gravel/coarse grain depositional material and cobble/boulder habitat) occurs between the Marcus Hook Bar (river kilometer 134) and the mouth of the Schuylkill River (river kilometer 148) (Sommerfield and Madsen, 2003). Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat exists from Tinicum Island (river kilometer 136) to the fall line in Trenton, NJ (river kilometer 211). Tracking of ten male and two female sturgeon belonging to the New York Bight DPS and presumed to be adults based on their size (> 150 centimeter fork length) indicated that each of the 12 sturgeon spent 7 to 70 days upriver of the salt-front, in April-July, the months of presumed spawning (Breece *et al.*, 2013). This indicates residency in low-salinity waters suitable for spawning. The sturgeon selected areas with mixed gravel and mud substrate (Breece *et al.*, 2013). Collectively, the 12 Atlantic sturgeon traveled as far upstream as Roebling, NJ (river kilometer 201), and inhabited areas of the river \pm 30 kilometers from the estimated salt front for 84 percent of the time with smaller peaks occurring 60 to 100 kilometers above the salt front for 16 percent of the time (Breece *et al.*, 2013). To date, eggs and larvae have not been documented to confirm that actual spawning is occurring in these areas. However, as noted below, the recent documented presence of young of the year in the Delaware River provides confirmation that spawning is 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 three 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 (rkm 130) until their tags transmissions also ended in October (Fisher, 2011). Twenty Atlantic sturgeon less than 30 centimeter FL (26.2 to 34.9 centimeter total length) were captured in the Delaware River during the timespan of September through November 2009; these fish were tracked for up to one year using a passive acoustic array (Calvo *et al.*, 2010; Fisher, 2011). The data collected indicate this life stage makes use of Delaware River habitats from river kilometer 105 to river kilometer 195 (Fisher, 2011). The sturgeon used several areas of the river from Deepwater (river kilometer 105) to Roebling (river kilometer 199) during late fall to early spring (Fisher, 2009; Calvo *et al.*, 2010). During the winter months, some remained in the Marcus Hook area while others moved upstream or downstream, exhibiting migrations in and out of the area (Calvo *et al.*, 2010; Fisher, 2011). From May to August, the tracked juveniles occurred between Philadelphia (river kilometer 150) and New Castle (river kilometer 100) (Fisher, 2011). By September 2010 (approximately one year after tracking began), only 3 of the 20 tagged

individuals had active tags (Fisher, 2011). One of these migrated upstream to the Newbold Island and Roebing area (river kilometer 195), but was back down in the lower tidal area within 3 weeks and was last detected at Tinicum Island (river kilometer 141) when the transmitter expired in October (Fisher, 2011). The other two remained in the Cherry Island Flats (river kilometer 113) and Marcus Hook Anchorage area until their tags transmissions also ended in October (Fisher, 2011).

Brundage and O'Herron (2014a) provide further evidence of the use of Marcus Hook area during winter months. Their trawl survey along rkm 127-139 from January 25-March 7, 2014 collected 36 Atlantic sturgeon (7 juveniles, 29 YOY).

The Delaware Estuary is known to be a congregation area for sturgeon from multiple DPSs. Generally, non-natal late stage juveniles (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 six young of the year. For non YOY fish, most detections occurred 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; Breece 2011). 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); supporting the assumption that adults are only present in the river during spawning. 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).

Based on mixed-stock analysis, we have determined that Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: Gulf of Maine 7%; NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; and Carolina 0.5%. In the action area, any eggs, larvae, or young of the year (juveniles) would only originate from the New York Bight DPS because these life stages are restricted to their natal river. Subadults from any of the five DPSs could be present in the action area in the proportions noted above; this life stage is most likely to be in the action area from mid-April to mid-November although some subadults may overwinter in the river and be present year round. Adults are only likely to be present in the river for approximately a four week period from mid-April to mid-June, dependent on annual water temperature. Nearly all adults in the river are likely to originate from the New York Bight DPS, but tracking indicates that occasionally adults are present in rivers outside their DPS of origin.

Atlantic sturgeon are well distributed throughout the Delaware River and Bay and could be present year round in all of the river reaches; however, because of low tolerance to salinity, juveniles are restricted to waters above the salt line, which moves seasonally. Juveniles are only likely to be present in Reaches AA, A, B and upper portions of C. Based on the likely spawning sites at rkm 120-150 and 170-190, eggs are only likely to be present seasonally in Reach B and upstream of reach AA. Larvae and YOY can also be present in Reaches AA, A, B and upper portions of Reach C. Subadults and adults could be present in any of the reaches.

5.0 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include: dredging operations, water quality, scientific research, shipping and other vessel traffic and fisheries, and recovery activities associated with reducing those impacts.

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

We have undertaken several ESA section 7 consultations to address the effects of actions authorized, funded or carried out by Federal agencies. Each of those consultations sought to develop ways of reducing the probability of adverse impacts of the action on listed species. Consultations are detailed below.

5.1.1 Delaware River – Philadelphia to Trenton Federal Navigation Project – Dredging

The Delaware River Philadelphia to Trenton Federal Navigation Channel is maintained by the USACE. As explained in the Consultation History section above, a batched consultation was completed in 1996 between NMFS and the USACE on the effects of the USACE's authorization

and completion of several Federal navigation projects, including the Philadelphia to Trenton project, as well as their regulatory dredging program. The Opinion was reinstated in 1998 with an amendment issued in 1999. The amended Opinion included an Incidental Take Statement exempting the annual take (entrainment and mortality) of four shortnose sturgeon, four loggerhead, one Kemp's ridley, and one green sea turtle. This take exemption applied to the Philadelphia to Trenton project, maintenance of the 40-foot Philadelphia to the Sea channel, and the USACE regulatory program where private dredging activities are authorized.

Dredging in the Philadelphia to Trenton project has resulted in shortnose sturgeon mortality and may have affected shortnose sturgeon distribution and foraging habitat. In mid-March 1996, three subadult shortnose sturgeon were found in a dredge discharge pool on Money Island, near Newbold Island. The dead sturgeon were found on the side of the spill area into which the hydraulic pipeline dredge was pumping, and the presence of large amounts of roe in two specimens and minimal decomposition indicates that the fish were alive and in good condition prior to entrainment. In January 1998, three shortnose sturgeon were discovered in the hydraulic maintenance dredge spoil in the Florence to Trenton section of the upper Delaware River. These fish also appeared to have been alive and in good condition prior to entrainment.

Dredging was being conducted in the Kinkora and Florence ranges when takes occurred; this area overlaps with where shortnose sturgeon are known to overwinter in large aggregations. Since dredging involves removing the bottom material down to a specified depth, the benthic environment could be severely impacted by dredging operations. As shortnose sturgeon are benthic species, the alteration of the benthic habitat could have affected sturgeon prey distribution and/or foraging ability. Since 1998, the USACE has been avoiding dredging in the overwintering area during the time of year when shortnose sturgeon are present. Habitats affected by the Philadelphia to Trenton project include foraging, overwintering and nursery habitats. Since 1998, no sturgeon mortalities have been observed.

5.1.2 Delaware River – Philadelphia to the Sea Federal Navigation Project

As noted in the Consultation History section, the existing 40 foot Philadelphia to the Sea navigation project is maintained with hopper and cutterhead dredges annually. As noted above, an Opinion was issued in 1996 and amended in 1999 that considered the effects of the maintenance of this project on shortnose sturgeon and sea turtles. This Opinion was replaced with a new Opinion issued by us on August 1, 2013; this Opinion considered the effects of maintenance of the 40' channel until such a time as it was deepened to 45' (expected to be completed in 2017). In that Opinion, we estimated the following level of incidental take (lethal):

- One Northwest Atlantic DPS loggerhead sea turtle or one Kemp's ridley sea turtle; and,
- One shortnose sturgeon; and,
- One Atlantic sturgeon from the Gulf of Maine, New York Bight, Chesapeake Bay or South Atlantic DPS.

The Philadelphia District Endangered Species Monitoring Program began in August 1992. Since that time, all hopper dredge operations conducted downstream of the Delaware Memorial Bridge between May and November have used endangered species observers to monitor for interactions with sea turtles (monitoring for sturgeon was required in the 2013 Opinion). Two sturgeon were

entrained during separate hopper dredge activities in the fall of 2014; the first (10/24/2014) was a fresh dead juvenile Atlantic sturgeon, while the second (11/26/2014) was a live Atlantic sturgeon (approximately 12 inches). Several sea turtles have been entrained during hopper dredging operations including two loggerheads in August 1993 and one loggerhead on June 22, 1994. Relocation trawling was conducted in 1994, and eight loggerheads were captured and relocated away from the channel. On November 13, 1995 one loggerhead was entrained by a hopper dredge working in the channel. On July 27, 2005, fresh loggerhead parts were observed in the hopper basket during two different loads. Outside of the disposal site inspectors working at upland disposal areas, no endangered species observers have been deployed during any cutterhead dredging operations for this project or at any hopper dredge operation upstream of the Delaware Memorial Bridge.

Summary of Effects of Deepening to date

The deepening project began in March 2010. Between March and September, 2010, approximately three million cy of material was removed via cutterhead dredge from Reach C. The disposal site was inspected daily for evidence of entrained sturgeon. No shortnose sturgeon or their parts were observed during the dredging operations. Dredging to execute contract 2, Reach B began in November 2011 and was completed in December 2011 with approximately one million cy of material removed. No sturgeon or their parts were observed at the disposal site. Contract 3, deepening of the upper portion of Reach A, was carried out from September 2012 through February 2013. Most dredging was accomplished with a cutterhead dredge but a hopper dredge was used for a limited amount of the dredging. The total volume removed was 1,259,165 cy. No sturgeon or their parts were observed during dredging or at the disposal sites. Contract 4, deepening of Reach D, was carried out between February and June 2013. The work, removing 1,149,946 cy of material, was largely completed with a hopper dredge and with a mechanical dredge used in areas where the hopper dredge was not effective. No sturgeon or their parts were observed during dredging or at the disposal sites.

Maintenance of the 45' channel has occurred in areas where shoaling has occurred such that depths are shallower than 45'. One Atlantic sturgeon has been observed during maintenance dredging to date (entrained alive in May 2013).

5.1.3 Crown Landing LNG Project

On May 23, 2006, we issued an Opinion to the Federal Energy Regulatory Commission (FERC) and the USACE regarding the effects of the issuance of an Order by FERC to British Petroleum/Crown Landing LLC (Crown Landing) to site, construct and operate a Liquefied Natural Gas (LNG) import terminal on the banks of Delaware River and the effects of the USACE issuing two permits to Crown Landing for the construction of this facility. The Opinion included an ITS exempting the take (lethal entrainment in cutterhead dredge) of up to 3 shortnose sturgeon during the initial dredging needed to create the berthing area and the death of up to an additional 3 shortnose sturgeon over the first ten years of maintenance dredging permitted by the USACE. As explained in the "Effects of the Action" section of this Opinion, only transient shortnose sturgeon are likely to occur in the project area and all other effects on shortnose sturgeon and their habitat are likely to be insignificant or discountable. The Opinion also concluded that the project is not likely to alter the Delaware River in a way that would make

the action area unsuitable for use as a migratory pathway for any life stage of shortnose sturgeon. In the Opinion, we concluded that the proposed action was not likely to adversely affect listed sea turtles. To date, the proposed project has not been constructed. Due to issues related to Coastal Zone Management Act consistency determinations, it is currently unknown whether the project will move forward as planned or whether it will be surrendered or modified.

5.1.4 Salem and Hope Creek Nuclear Generating Stations

PSEG Nuclear operates two nuclear power plants pursuant to licenses issued by the U.S. Nuclear Regulatory Commission (NRC). These facilities are the Salem and Hope Creek Generating Stations (Salem and HCGS), which are located on adjacent sites within a 740-acre parcel of property at the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. Salem Unit 1 is authorized to operate until 2036 and Salem Unit 2 until 2040. Hope Creek is authorized to operate until 2046.

Consultation pursuant to Section 7 of the ESA between NRC and NMFS on the effects of the operation of these facilities has been ongoing since 1979. A Biological Opinion was issued by us in April 1980 in which we concluded that the ongoing operation of the facilities was not likely to jeopardize the continued existence of shortnose sturgeon. Consultation was reinitiated in 1988 due to the documentation of impingement of sea turtles at the Salem facility. An Opinion was issued on January 2, 1991 in which we concluded that the ongoing operation was not likely to jeopardize shortnose sturgeon, Kemp's ridley, green or loggerhead sea turtles. Consultation was reinitiated in 1992 due to the number of sea turtle impingements at the Salem intake exceeding the number exempted in the 1991 Incidental Take Statement. A new Opinion was issued on August 4, 1992. Consultation was again reinitiated in January 1993 when the number of sea turtle impingements exceeded the 1992 ITS with an Opinion issued on May 14, 1993. In 1998 the NRC requested that we modify the Reasonable and Prudent Measures and Terms and Conditions of the ITS, and, specifically, remove a sea turtle study requirement. We responded to this request in a letter dated January 21, 1999. Accompanying this letter was a revised ITS which served to amend the May 14, 1993 Opinion. The 1999 ITS exempts the annual take (capture at intake with injury or mortality) of 5 shortnose sturgeon, 30 loggerhead sea turtles, 5 green sea turtles, and 5 Kemp's ridleys.

We completed consultation with NRC in 2014 and issued a Biological Opinion considering the effects of operations under the renewed operating licenses (issued in 2011). In the Opinion we concluded that the continued operation of the Salem 1, Salem 2 and Hope Creek Nuclear Generating Stations through the duration of extended operating licenses may adversely affect but is not likely to jeopardize the continued existence of any listed species. As described in the tables below, this ITS exempts take of shortnose and Atlantic sturgeon, loggerhead, green and Kemp's ridley sea turtles (injure, kill, capture or collect) resulting from the operation of the cooling water system. The ITS also exempts the capture of one live shortnose sturgeon and one live Atlantic sturgeon (originating from any of the 5 DPSs) during gillnet sampling associated with the Radiological Environmental Monitoring Program for either Salem 1, Salem 2, or Hope Creek.

As explained in the Opinion, we have determined that the IBMWP, required by the NJPDES permit, including the baywide trawl survey and beach seine sampling, is an interrelated activity.

In the Effects of the Action section, we considered the effects of the IBMWP as required by the NJPDES permit issued to PSEG for the operation of Salem 1 and 2. We estimated that the continuation of the bottom trawl survey will result in the non-lethal capture of 9 shortnose sturgeon, 11 Atlantic sturgeon (6 NYB, 2 CB, and 3 SA, GOM or Carolina DPS) and 5 sea turtles (4 loggerheads and 1 Kemp’s ridley or green). We also expect the beach seine survey to result in the non-lethal capture of one Atlantic sturgeon (likely NYB DPS origin) and one shortnose sturgeon. This ITS exempts this amount of take (“capture” or “collect”) of live shortnose sturgeon, Atlantic sturgeon and sea turtles captured during these surveys.

Impingement or Collection of Shortnose Sturgeon at the Trash Bars

Salem Unit 1	Salem Unit 2	Total Unit 1 and 2
12 (10 dead, 5 due to impingement)	14 (12 dead, 6 due to impingement)	26 (22 dead, 11 due to impingement)

Impingement or Collection of Atlantic Sturgeon at the Trash Bars

	Salem Unit 1	Salem Unit 2	Total Unit 1 and 2
All age classes and DPSs combined	92 (28 dead, 8 due to impingement)	108 (33 dead, 10 due to impingement)	200 (61 dead, 18 due to impingement)
Juveniles (NYB DPS)	88 (27 dead, 7 due to impingement)	104 (32 dead, 9 due to impingement)	192 (59 dead, 16 due to impingement)
Subadult or adult TOTAL:	4 (1 dead due to impingement)	4 (1 dead due to impingement)	8 (2 dead due to impingement)
Sub adult or adult NYB DPS	3 (1 dead due to impingement)	3 (1 due to impingement)	6 (2 dead due to impingement)
Sub adult or adult CB DPS	1 dead or alive from either the CB, SA, GOM or Carolina DPS	1 dead or alive from either the CB, SA, GOM or Carolina DPS	Total of 2 from the CB, SA, GOM and/or Carolina DPS
Subadult or adult SA DPS			
Subadult or adult GOM DPS			
Subadult or adult Carolina DPS			

Impingement/Collection of Atlantic Sturgeon at the Traveling Screens

	Salem Unit 1	Salem Unit 2	Total Units 1 and 2
NYB DPS	138 (12 injury or mortality)	162 (14 injury or mortality)	300 (26 injury or mortality)

Impingement/Collection of Sea Turtles at the Trash Bars

	Salem Unit 1	Salem Unit 2
Loggerhead	4 (1 dead)	5 (1 dead)
Green	One at Unit 1 or Unit 2 (alive or dead)	
Kemp’s Ridley	2 (1 dead)	2 (dead)

5.1.5 Emergency Clean-Up Actions associated with the M/V Athos I Spill

On November 26, 2004, during docking operations at the Citgo facility in Paulsboro, New Jersey (RM 90), the hull of the tank vessel M/V Athos I was punctured by a submerged object causing the discharge of approximately 473,000 gallons of crude oil (low aromatic, sweet, product code: 1267) into the Delaware River. The emergency cleanup action was initiated under US Coast Guard (USCG) oversight. Pursuant to the emergency consultation procedures outlined in Section 7 of the ESA, the USCG initiated emergency consultation on the effects of the cleanup action on shortnose sturgeon. In a letter dated January 20, 2006, we concluded that “while it is likely that the spill itself negatively impacted shortnose sturgeon in the Delaware River, likely by introducing contaminants into the environment and by altering normal behaviors, there is no evidence that suggests that the cleanup and response activities had an adverse effect on shortnose sturgeon. The removal of oil by mechanical means and the removal of oiled wildlife likely beneficially affected shortnose sturgeon as it minimized, to the extent possible, the potential for shortnose sturgeon to come into contact with the oil or to be contaminated by toxins through the food chain.” In this letter, we concurred with the determination made by the USCG that the response activities associated with the November 26, 2004 spill of the M/V Athos I did not adversely affect shortnose sturgeon. No oiled sturgeon or sea turtles were documented during the spill or during clean-up activities.

5.1.6 Scientific Studies

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

Hal Brundage of Environmental Research and Consulting, Inc. holds a scientific research permit (#14604, which replaces his previously held permit #1486) authorizing research on relative abundance, reproduction, juvenile recruitment, temporal and spatial distributions, and reproductive health of shortnose sturgeon. Methods would include capturing up to 1,000 adult and juvenile shortnose sturgeon annually via gill net, trammel net, and trawl net; measure; weigh; scan (for tags); PIT and Floy T-bar tag; and sample tissue for genetic analysis. A subset of 30 adults and 30 juveniles annually will be tagged with acoustic transmitters. Another subset of 24 adults annually will be examined internally using laparoscopic techniques, blood drawn for analysis, and a biopsy of the gonads taken. Up to 500 eggs and larvae will be collected by artificial substrate, D-frame ichthyoplankton net, and/or epibenthic sled. The unintentional mortality of one adult or juvenile shortnose sturgeon is anticipated over the life of the permit. This permit expires on April 19, 2016.

Mr. Brundage also holds a scientific research permit (#16438) authorizing research on Atlantic sturgeon. Mr. Brundage is authorized to capture and tag 384 juvenile, subadult and adult Atlantic sturgeon as well as 500 Atlantic sturgeon eggs or larvae. The unintentional mortality of one adult or juvenile shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on April 5, 2017.

Dr. Dewayne Fox of Delaware State University holds a scientific research permit (#16507)

authorizing research on Atlantic and shortnose sturgeon. Dr. Fox is authorized to capture and tag 510 Atlantic sturgeon and 100 shortnose sturgeon as well as 300 Atlantic sturgeon eggs. This permit expires on April 5, 2017. No mortality is authorized by this permit.

Delaware Fish and Wildlife (DFW) holds a scientific research permit (#16431) authorizing research targeting early juvenile Atlantic sturgeon (<600 mm TL) in the Delaware estuary. DFW is authorized to capture, handle and tag 240 juvenile Atlantic sturgeon. No mortality is anticipated or authorized by the permit. The permit expires on April 5, 2017.

5.1.7 Vessel Operations

Potential adverse effects from federal vessel operations in the action area of this consultation include operations of the U.S. Navy (USN) and the U.S. Coast Guard (USCG), which maintain the largest federal vessel fleets, the EPA, the National Oceanic and Atmospheric Administration (NOAA), and the USACE. We have conducted formal consultations with the USCG, the USN, EPA and NOAA on their vessel operations. In addition to operation of USACE vessels, we have consulted with the USACE to provide recommended permit restrictions for operations of contract or private vessels around whales. Through the section 7 process, where applicable, we have and will continue to establish conservation measures for all these agency vessel operations to avoid adverse effects to listed species. Refer to the biological opinions for the USCG (September 15, 1995; July 22, 1996; and June 8, 1998) and the USN (May 15, 1997) for detail on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures. No interactions with sturgeon or sea turtles have been reported with any of the vessels considered in these Opinions.

5.1.8 Other Federally Authorized Actions

We have completed several informal consultations on effects of in-water construction activities in the Delaware River permitted by USACE. This includes several dock, pier and bank stabilization 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 USACE. All of the dredging was with a mechanical or cutterhead dredge. No interactions with shortnose or Atlantic sturgeon have been reported in association with any of these projects.

5.2 State or Private Actions in the Action Area

5.2.1 State Authorized Fisheries

Atlantic and shortnose sturgeon and sea turtles may be vulnerable to capture, injury and mortality in fisheries occurring in state waters. The action area includes portions of Pennsylvania, New Jersey and Delaware state waters within the Delaware River and Delaware Bay. 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 are currently working with several states (including Delaware and New Jersey) on applications for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no permits have been issued to the states surrounding the Delaware River/Bay¹⁴. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon.

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. Eels are typically caught with hook and line or with eel traps and may also be caught with fyke nets. Sturgeon and sea turtles 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. 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. Atlantic croaker are seasonally present in Delaware Bay; fishing occurs for this species in the Bay but not in the river.

Recreational fisheries for Atlantic croaker are likely to use hook and line; commercial fisheries targeting croaker primarily use otter trawls. The average annual bycatch of loggerhead sea turtles in bottom otter trawl gear used in the Atlantic croaker fishery was estimated to be 70 loggerhead sea turtles (Warden 2011). Additional information on sea turtle interactions with gillnet gear, including gillnet gear used in the Atlantic croaker fishery, has also been recently published by Murray (2009a, 2009b). The average annual bycatch of loggerhead sea turtles in gillnet gear used in the Atlantic croaker fishery, based on VTR data from 2002-2006, was estimated to be 11 per year with a 95% CI of 3-20 (Murray 2009b). A quantitative assessment of the number of Atlantic sturgeon captured in the croaker fishery is not available. Mortality rates of Atlantic sturgeon in commercial trawls have been estimated at 5%. 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 for boats with federal permits only. Because of the area where the fishery occurs, we do not anticipate any interactions with shortnose sturgeon.

Horseshoe crabs

ASMFC manages horseshoe crabs through an Interstate Fisheries Management Plan that sets state quotas, and allows states to set closed seasons. Horseshoe crabs are present in Delaware

¹⁴ A Section 10 (a)(1)(b) permit was issued to the State of Georgia (Permit No. 16645) on January 8, 2013 exempting the incidental take of shortnose sturgeon and Atlantic sturgeon (SA, Carolina and CB DPS) in the State shad fishery. A Section 10 (a)(1)(b) permit was issued to the State of North Carolina on July 9, 2014 to exempt incidental take of Atlantic sturgeon from all 5 DPSs in the North Carolina inshore gillnet fishery.

Bay. In New Jersey, there is currently a moratorium on the harvest of horseshoe crabs and horseshoe crab eggs for an indeterminate period of time. The law also prohibits the possession of horseshoe crabs and horseshoe crab eggs except for those individuals in possession of a scientific collecting permit, allowing them to possess horseshoe crabs or horseshoe crab eggs for research or educational purposes only, and those fishermen utilizing horseshoe crabs as bait must provide adequate documentation that the horseshoe crabs in their possession were not harvested in New Jersey. In Delaware, limited harvest of horseshoe crabs is allowed. Delaware's annual quota allocation is 100,000 male-only horseshoe crabs; with an open season of June 8 – December 31. 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 horseshoe crab fishery in the action area. Sea turtles are not known to be captured during horseshoe crab fishing. Shortnose sturgeon are unlikely to be captured in gear targeting horseshoe crabs given the location of fishing effort in the lower Bay.

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 the action area, fishing for river herring is prohibited. Limited fishing effort for shad continues to occur. Recreational shad fishing is currently allowed within the Delaware River with hook and line only; commercial fishing for shad occurs with gill nets, but only in Delaware Bay. In the past, it was estimated that over 100 shortnose sturgeon were captured annually in shad fisheries in the Delaware River, with an unknown mortality rate (O'Herron and Able 1985). Nearly all captures occurred in the upper Delaware River, upstream of the action area. No recent estimates of captures or mortality of shortnose or Atlantic sturgeon are available. In 2012, only one commercial fishing license was granted for shad in New Jersey. Shortnose and Atlantic sturgeon continue to be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to shortnose and Atlantic sturgeon are likely less than they were in the past.

Striped bass

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 or the mortality rate is available.

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). 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). Fishing for weakfish occurs in Delaware Bay.

As described in section 3.1.1, sea turtle bycatch in the weakfish fishery has occurred (Warden 2011; Murray 2009a, 2009b). The average annual bycatch of loggerhead sea turtles in bottom otter trawl gear used in the weakfish fishery was estimated to be 1 loggerhead sea turtle (Warden 2011). Additional information on sea turtle interactions with gillnet gear, including gillnet gear used in the weakfish fishery, has also been recently published by Murray (2009a, 2009b). The average annual bycatch of loggerhead sea turtles in gillnet gear used in the weakfish fishery, based on VTR data from 2002-2006, was estimated to be one (1) per year with a 95% CI of 0-1 (Murray 2009b).

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-stripped 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 0.02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007).

American lobster trap fishery

An American lobster trap fishery also occurs in Delaware Bay. This fishery is managed under the ASMFC's ISFMP. This fishery has also been identified as a source of gear causing injuries to and mortality of loggerhead and leatherback sea turtles as a result of entanglement in vertical buoy lines of the pot/trap gear. Between 2002 and 2008, the lobster trap fishery in state waters was verified as the fishery involved in at least 27 leatherback entanglements in the Northeast Region. All entanglements involved the vertical line of the gear. These verified/confirmed entanglements occurred in Maine, Massachusetts, and Rhode Island state waters from June through October (Northeast Region STDN database). While no entanglements in lobster gear have been reported for Delaware Bay, the potential for future entanglement exists. Atlantic and shortnose sturgeon are not known to interact with lobster trap gear (NMFS 2012).

5.3 Other Impacts of Human Activities in the Action Area

5.3.1 Contaminants and Water Quality

Historically, shortnose sturgeon were rare in the area below Philadelphia, likely as a result of poor water quality precluding migration further downstream. However, in the past 20 to 30 years, the water quality has improved and sturgeon have been found farther downstream. It is likely that contaminants remain in the water and in the action area, albeit to reduced levels.

Point source discharges (i.e., municipal wastewater, 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 or receiving

waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival.

Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from coastal development, groundwater discharges, and industrial development. Chemical contaminants may also have an effect on sea turtle reproduction and survival. While the effects of contaminants on turtles are relatively unclear, pollution may be linked to the fibropapilloma virus that kills many turtles each year (NMFS 1997). If pollution is not the causal agent, it may make sea turtles more susceptible to disease by weakening their immune systems.

Contaminants have been detected in Delaware River fish. PCBs have been detected in elevated levels in several species of fish. Large portions of the Delaware River are bordered by highly industrialized waterfront development. Sewage treatment facilities, refineries, manufacturing plants and power generating facilities all intake and discharge water directly from the Delaware River. This results in large temperature variations, heavy metals, dioxin, dissolved solids, phenols and hydrocarbons which may alter the pH of the water eventually leading to fish mortality. Industrialized development, especially the presence of refineries, has also resulted in storage and leakage of hazardous material into the Delaware River. Presently 13 Superfund sites have been identified in Marcus Hook and one dumpsite has yet to be labeled as a Superfund site, but does contain hazardous waste. It is possible that the presence of contaminants in the action area may have adversely affected shortnose sturgeon abundance, reproductive success and survival.

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). 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 Keenlyne 1993). Available data suggest that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). Although there have not been any studies to assess the impact of contaminants on shortnose sturgeon, elevated levels of environmental contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Cameron *et al.* 1992; Longwell *et al.* 1992), reduced egg viability (Von Westernhagen *et al.* 1981; Hansen 1985; Mac and Edsall 1991), and reduced survival of larval fish (Berlin *et al.* 1981; Giesy *et al.* 1986). Some researchers have speculated that PCBs may reduce the shortnose sturgeon's resistance to fin rot (Dovel *et al.* 1992).

Although there is scant information available on levels of contaminants in shortnose sturgeon tissues, some research on other, related species indicates that concern about effects of contaminants on the health of sturgeon populations is warranted. Detectable levels of chlordane, DDE, DDT, and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were

found in pallid sturgeon tissue from the Missouri River (US Fish and Wildlife Service 1993). These compounds may affect physiological processes and impede a fish's ability to withstand stress. PCBs are believed to adversely affect reproduction in pallid sturgeon (Ruelle and Keenlyne 1993). Ruelle and Henry (1992) found a strong correlation between fish weight $r = 0.91$, $p < 0.01$, fish fork length $r = 0.91$, $p < 0.01$, and DDE concentration in pallid sturgeon livers, indicating that DDE concentration increases proportionally with fish size.

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 semi-volatile 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 and DDE (an organochlorine pesticide) were detected in the "adverse effect" 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. While no directed studies of chemical contamination in shortnose sturgeon in the Delaware River have been undertaken, it is evident that the heavy industrialization of the Delaware River is likely adversely affecting this population.

Excessive turbidity due to coastal development and/or construction sites could influence sea turtle foraging ability. Turtles are not very easily affected by changes in water quality or increased suspended sediments, but if these alterations make habitat less suitable for turtles and hinder their capability to forage, eventually they would tend to leave or avoid these less desirable areas (Ruben and Morreale 1999).

Marine debris (*e.g.*, discarded fishing line or lines from boats) can entangle turtles in the water and drown them. Turtles commonly ingest plastic or mistake debris for food. Chemical contaminants may also have an effect on sea turtle reproduction and survival. Excessive turbidity due to coastal development and/or construction sites could influence sea turtle foraging ability. As mentioned previously, turtles are not very easily affected by changes in water quality or increased suspended sediments, but if these alterations make habitat less suitable for turtles and hinder their capability to forage, eventually they would tend to leave or avoid these less desirable areas (Ruben and Morreale 1999). Noise pollution has been raised, primarily, as a concern for marine mammals but may be a concern for other marine organisms, including sea turtles.

5.3.2 Private and Commercial Vessel Operations

Private and commercial vessels, including fishing vessels, operating in the action area of this consultation also have the potential to interact with sea turtles. Approximately 3,000 cargo vessels transit the Delaware River annually as well as numerous smaller commercial and recreational vessels. The effects of fishing vessels, recreational vessels, or other types of commercial vessels on listed species may involve disturbance or injury/mortality due to collisions or entanglement in anchor lines. Sea turtles are known to be vulnerable to vessel strikes; however, no estimate of the number of vessel strikes in the action area is available.

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 vessel strike. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to Atlantic sturgeon that are larger and for which vessel strikes have been documented more frequently. However, available evidence, including records from the Delaware, Hudson, and Kennebec Rivers, suggests that shortnose sturgeon at least occasionally interact with vessels, as evidence by wounds that appear to be caused by propellers. In the action area, suspected vessel strike mortalities have been recorded. 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. 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. It is unknown if those lacerations were caused pre- or post-mortem. At this time, we have no information on the characteristics of vessels that are most likely to interact with shortnose sturgeon; however, we assume that fast moving vessels operating in shallow water or areas with limited clearance between the hull or propeller and the bottom, create the highest risk. This is because we expect this would be the scenario when a sturgeon would be least likely to be able to avoid an interaction. At this time, we are not able to predict the number of interactions between vessels and shortnose sturgeon that occur in the action area each year.

As noted in the 2007 Status Review and the final listing rules, vessel strikes have been identified as a threat to Atlantic sturgeon. While the exact number of Atlantic sturgeon killed as a result of being struck by boat hulls or propellers is unknown, it is an area of concern. Brown and Murphy (2010) examined 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 or from the spawning grounds.

The factors relevant to determining the risk to Atlantic sturgeon from vessel strikes are currently unknown, but they may be related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of Atlantic sturgeon in the area (e.g., foraging, migrating, etc.). It is unknown to what extent the mortalities documented by Brown and Murphy (2010) accurately characterize the extent of vessel strikes in the Delaware River, but as it is unlikely that all Atlantic sturgeon that died in the time period of the study were observed by the authors, it is likely that there are other undocumented mortalities resulting from vessel strikes as well as from other sources. Vessel interactions are thought to cause the death of several Atlantic sturgeon in the Delaware River each year.

6.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change in the action area (i.e., the Delaware River and estuary) and how listed sea turtles and sturgeon may be affected by those predicted environmental changes over the life of the proposed action (i.e., between now and 2027). Generally speaking, climate change may be relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of an Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Effects of the proposed action that are relevant to climate change are included in the Effects of the Action section below (section 7.0 below).

6.1 Background Information on Global 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) and precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b); these trends are most apparent over the past few decades. Information on future impacts of climate change in the action area is discussed below.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3°-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 Delaware River, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that the rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 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 un-impacted, free-flowing rivers (Palmer *et al.* 2008).

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

6.2 Species Specific Information on Climate Change Effects

6.2.1 Loggerhead Sea Turtles

The most recent Recovery Plan for loggerhead sea turtles as well as the 2009 Status Review Report identifies global climate change as a threat to loggerhead sea turtles. However, trying to assess the likely effects of climate change on loggerhead sea turtles is extremely difficult given the uncertainty in all climate change models and the difficulty in determining the likely rate of temperature increases and the scope and scale of any accompanying habitat effects. Additionally, no significant climate change-related impacts to loggerhead sea turtle populations have been observed to date. Over the long-term, climate change related impacts are expected to influence biological trajectories on a century scale (Parmesan and Yohe 2003). As noted in the 2009 Status Review (Conant *et al.* 2009), impacts from global climate change induced by human activities are likely to become more apparent in future years (Intergovernmental Panel on Climate Change (IPCC) 2007). Climate change related increasing temperatures, sea level rise, changes in ocean productivity, and increased frequency of storm events may affect loggerhead sea turtles.

Increasing temperatures are expected to result in rising sea levels (Titus and Narayanan 1995 in Conant *et al.* 2009), which could result in increased erosion rates along nesting beaches. Sea level rise could result in the inundation of nesting sites and decrease available nesting habitat (Daniels *et al.* 1993; Fish *et al.* 2005; Baker *et al.* 2006). The BRT noted that the loss of habitat as a result of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis *et al.* 2006; Baker *et al.* 2006; both in Conant *et al.* 2009). Along developed coastlines, and especially in areas where erosion control structures have been constructed to limit shoreline movement,

rising sea levels may cause severe effects on nesting females and their eggs as nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation. However, if global temperatures increase and there is a range shift northwards, beaches not currently used for nesting may become available for loggerhead sea turtles, which may offset some loss of accessibility to beaches in the southern portions of the range.

Climate change has the potential to result in changes at nesting beaches that may affect loggerhead sex ratios. Loggerhead sea turtles exhibit temperature-dependent sex determination. Rapidly increasing global temperatures may result in warmer incubation temperatures and highly female-biased sex ratios (*e.g.*, Glen and Mrosovsky 2004; Hawkes *et al.* 2009); however, to the extent that nesting can occur at beaches further north where sand temperatures are not as warm, these effects may be partially offset. The BRT specifically identified climate change as a threat to loggerhead sea turtles in the neritic/oceanic zone where climate change may result in future trophic changes, thus impacting loggerhead prey abundance and/or distribution. In the threats matrix analysis, climate change was considered for oceanic juveniles and adults and eggs/hatchlings. The report states that for oceanic juveniles and adults, “although the effect of trophic level change from...climate change...is unknown it is believed to be very low.” For eggs/hatchlings the report states that total mortality from anthropogenic causes, including sea level rise resulting from climate change, is believed to be low relative to the entire life stage. The BRT concludes that only limited data are available on past trends related to climate effects on loggerhead sea turtles; current scientific methods are not able to reliably predict the future magnitude of climate change, associated impacts, whether and to what extent some impacts will offset others, or the adaptive capacity of this species.

Following the publication of the 2009 Status Review, Van Houtan and Halley (2011) developed climate forcing models to investigate loggerhead nesting (considering juvenile recruitment and breeding remigration) in the North Pacific and Northwest Atlantic. These models found that climate conditions/oceanographic influences explain loggerhead nesting variability, with climate models alone explaining an average 60% (range 18%-88%) of the observed nesting changes over the past several decades. In terms of future nesting projections, modeled climate data show a future positive trend for Florida nesting, with increases through 2040 as a result of the Atlantic Multidecadal Oscillation signal.

6.2.2 Kemp’s Ridley Sea Turtles

The recovery plan for Kemp’s ridley sea turtles (NMFS *et al.* 2011) identifies climate change as a threat; however, as with the other species discussed above, no significant climate change-related impacts to Kemp’s ridley sea turtles have been observed to date. Atmospheric warming could cause habitat alteration which may change food resources such as crabs and other invertebrates. It may increase hurricane activity, leading to an increase in debris in nearshore and offshore waters, which may result in an increase in entanglement, ingestion, or drowning. In addition, increased hurricane activity may cause damage to nesting beaches or inundate nests with sea water. Atmospheric warming may change convergence zones, currents and other oceanographic features that are relevant to Kemp's ridleys, as well as change rain regimes and levels of nearshore runoff.

Considering that the Kemp's ridley has temperature-dependent sex determination (Wibbels 2003) and the vast majority of the nesting range is restricted to the State of Tamaulipas, Mexico, global warming could potentially shift population sex ratios towards females and thus change the reproductive ecology of this species. A female bias is presumed to increase egg production (assuming that the availability of males does not become a limiting factor) (Coyne and Landry 2007) and increase the rate of recovery; however, it is unknown at what point the percentage of males may become insufficient to facilitate maximum fertilization rates in a population. If males become a limiting factor in the reproductive ecology of the Kemp's ridley, then reproductive output in the population could decrease (Coyne 2000). Low numbers of males could also result in the loss of genetic diversity within a population; however, there is currently no evidence that this is a problem in the Kemp's ridley population (NMFS *et al.* 2011). Models (Davenport 1997, Hulin and Guillon 2007, Hawkes *et al.* 2007, all referenced in NMFS *et al.* 2011) predict very long-term reductions in fertility in sea turtles due to climate change, but due to the relatively long life cycle of sea turtles, reductions may not be seen until 30 to 50 years in the future.

Another potential impact from global climate change is sea level rise, which may result in increased beach erosion at nesting sites. Beach erosion may be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents. In the case of the Kemp's ridley where most of the critical nesting beaches are undeveloped, beaches may shift landward and still be available for nesting. The Padre Island National Seashore (PAIS) shoreline is accreting, unlike much of the Texas coast, and with nesting increasing and the sand temperatures slightly cooler than at Rancho Nuevo, PAIS could become an increasingly important source of males for the population.

6.2.3 Green Sea Turtles

The five year status review for green sea turtles (NMFS and USFWS 2007d) notes that global climate change is affecting green sea turtles and is likely to continue to be a threat. There is an increasing female bias in the sex ratio of green turtle hatchlings. While this is partly attributable to imperfect egg hatchery practices, global climate change is also implicated as a likely cause. This is because warmer sand temperatures at nesting beaches are likely to result in the production of more female embryos. At least one nesting site, Ascension Island, has had an increase in mean sand temperature in recent years (Hays *et al.* 2003 in NMFS and USFWS 2007d). Climate change may also affect nesting beaches through sea level rise, which may reduce the availability of nesting habitat and increase the risk of nest inundation. Loss of appropriate nesting habitat may also be accelerated by a combination of other environmental and oceanographic changes, such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion. Oceanic changes related to rising water temperatures could result in changes in the abundance and distribution of the primary food sources of green sea turtles, which in turn could result in changes in behavior and distribution of this species. Seagrass habitats may suffer from decreased productivity and/or increased stress due to sea level rise, as well as salinity and temperature changes (Short and Neckles 1999; Duarte 2002).

As noted above, the increasing female bias in green sea turtle hatchlings is thought to be at least partially linked to increases in temperatures at nesting beaches. However, at this time, we do not know how much of this bias is due to hatchery practice and how much is due to increased sand temperature. Because we do not have information to predict the extent and rate to which sand temperatures at the nesting beaches used by green sea turtles may increase in the short-term future, we cannot predict the extent of any future bias. Also, we do not know to what extent to which green sea turtles may be able to cope with this change by selecting cooler areas of the beach or shifting their nesting distribution to other beaches at which increases in sand temperature may not be experienced.

6.2.4 *Leatherback sea turtles*

Global climate change has been identified as a factor that may affect leatherback habitat and biology (NMFS and USFWS 2007b); however, no significant climate change related impacts to leatherback sea turtle populations have been observed to date. Over the long term, climate change related impacts will likely influence biological trajectories in the future on a century scale (Parmesan and Yohe 2003). Changes in marine systems associated with rising water temperatures, changes in ice cover, salinity, oxygen levels and circulation including shifts in ranges and changes in algal, plankton, and fish abundance could affect leatherback prey distribution and abundance. Climate change is expected to expand foraging habitats into higher latitude waters and some concern has been noted that increasing temperatures may increase the female:male sex ratio of hatchlings on some beaches (Morosovsky *et al.* 1984 and Hawkes *et al.* 2007 in NMFS and USFWS 2007b). However, due to the tendency of leatherbacks to have individual nest placement preferences and deposit some clutches in the cooler tide zone of beaches, the effects of long-term climate on sex ratios may be mitigated (Kamel and Mrosovsky 2004 in NMFS and USFWS 2007b).

Additional potential effects of climate change on leatherbacks include range expansion and changes in migration routes as increasing ocean temperatures shift range-limiting isotherms north (Robinson *et al.* 2008). Leatherbacks have expanded their range in the Atlantic north by 330 km in the last 17 years as warming has caused the northerly migration of the 15°C sea surface temperature (SST) isotherm, the lower limit of thermal tolerance for leatherbacks (McMahon and Hays 2006). Leatherbacks are speculated to be the best able to cope with climate change of all the sea turtle species due to their wide geographic distribution and relatively weak beach fidelity. Leatherback sea turtles may be most affected by any changes in the distribution of their primary jellyfish prey, which may affect leatherback distribution and foraging behavior (NMFS and USFWS 2007b). Jellyfish populations may increase due to ocean warming and other factors (Brodeur *et al.* 1999; Attrill *et al.* 2007; Richardson *et al.* 2009). However, any increase in jellyfish populations may or may not impact leatherbacks as there is no evidence that any leatherback populations are currently food-limited.

Increasing temperatures are expected to result in rising sea levels (Titus and Narayanan 1995 in Conant *et al.* 2009), which could result in increased erosion rates along nesting beaches. Sea level rise could result in the inundation of nesting sites and decrease available nesting habitat (Fish *et al.* 2005). This effect would potentially be accelerated due to a combination of other

environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents. While there is a reasonable degree of certainty that climate change related effects will be experienced globally (*e.g.*, rising temperatures and changes in precipitation patterns), due to a lack of scientific data, the specific effects of climate change on this species are not quantifiable at this time (Hawkes *et al.* 2009).

6.2.5 Shortnose sturgeon

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

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

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

6.2.6 Atlantic sturgeon

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to affect the South Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, 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 salt wedge 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 salt wedge. It is unlikely that shifts in the location of the salt wedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

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

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

6.3 Effects of Climate Change in the Action Area

Available information on climate change related effects for the Delaware River largely focuses on effects that rising water levels may have on the human environment (Barnett *et al.* 2009) and the availability of water for human use (e.g., Ayers *et al.* 1994). Documents prepared by USACE for the deepening project have considered climate change (USACE 2009, 2011), with a focus on sea level rise and a change in the location of the salt line.

Kreeger *et al.* (2010) considers effects of climate change on the Delaware Estuary. Using the average of 14 models, an air temperature increase of 1.9-3.7°C over this century is anticipated, with the amount dependent on emissions scenarios. No predictions related to increases in river water temperature are provided. There is also a 7-9% increase in precipitation predicted as well as an increase in the frequency of short term drought, a decline in the number of frost days, and an increase in growing season length predicted by 2100.

The report notes that the Mid-Atlantic States are anticipated to experience sea level rise greater than the global average (GCRP, 2009). While the global sea level rise is largely attributed to melting ice sheets and expanding water as it warms, there is regional variation because of gravitational forces, wind, and water circulation patterns. In the Mid-Atlantic region, changing water circulation patterns are expected to increase sea level by approximately 10 cm over this century (Yin *et al.*, 2009 in Kreeger *et al.* 2010). Subsidence and sediment accretion also influence sea level rise in the Mid-Atlantic, including in the Delaware estuary. As described by Kreeger, postglacial settling of the land masses has occurred in the Delaware system since the last Ice Age. This settling causes a steady loss of elevation, which is called subsidence. Through the next century, subsidence is estimated to hold at an average 1-2 mm of land elevation loss per year (Engelhart *et al.*, 2009 in Kreeger *et al.* 2010). Rates of subsidence and accretion vary in different areas around the Delaware Estuary, but the greatest loss of shoreline habitat is expected to occur where subsidence is naturally high in areas that cannot accrete more sediment to compensate for elevation loss plus absolute sea-level rise. The net increase in sea-level compared to the change in land elevation is referred to as the rate of relative sea-level rise (RSRL). Kreeger states that the best estimate for RSLR by the end of the century is 0.8 to 1.7 m in the Delaware Estuary.

Ross *et al.* (2015) sought to determine which variables have an influence on the salinity of the Delaware Estuary. By creating statistical models relying on long-term (1950-present) data collected by USGS and the Haskin Shellfish Research Laboratory, the authors found that after accounting for the influence of streamflow and seasonal effects, several locations in the estuary show significant upward trends in salinity. These trends are positively correlated with sea level rise, and salinity appears to be rising 2.5-4.4 PPT per meter of sea level rise.

Sea level rise combined with more frequent droughts and increased human demand for water are predicted to result in a northward movement of the salt wedge in the Delaware River (Collier 2011). Currently, the normal average location of the salt wedge is at approximately rkm 114. Collier predicts that without mitigation (e.g., increased release of flows into downstream areas of the river), at high tide in the peak of the summer during extreme drought conditions, the salt line could be as far upstream as rkm 183 in 2050 and rkm 188 in 2100. The farthest north the salt line has historically been documented was approximately rkm 166 during a period of severe drought in 1965; thus, he predicts that over time, during certain extreme conditions, the salt line could shift up to 18 km further upstream by 2050 and 23 km further upstream by 2100.

A hydrologic model for the Delaware River, incorporating predicted changes in temperature and precipitation was compiled by Hassell and Miller (1999). The model results indicate that when only the temperature increase is input to the hydrologic model, the mean annual streamflow

decreased, the winter flows increased due to increased snowmelt, and the mean position of the salt front moved upstream. When only the precipitation increase was input to the hydrologic model, the mean annual streamflow increased, and the mean position of the salt front moved further downstream. However, when both the temperature and precipitation increase were input to the hydrologic model the mean annual streamflow changed very little, with a small increase during the first four months of the year.

Water temperature in the Delaware River varies seasonally. A 2007 examination of long-term trends in Delaware River water temperature shows no indication of any long-term trends in these seasonal changes (BBL Sciences 2007). Monthly mean temperature in 2001 compares almost identically to long-term monthly mean temperatures for the period from 1964 to 2000, with lowest temperatures recorded in April (10–11°C) and peak temperatures observed in August (approximately 26–27°C). While water temperature rises have been observed in other mid-Atlantic rivers (e.g., a 2°C increase in the Hudson River from the 1960s to 2000s (Pisces 2008)), a similar trend does not currently appear in the Delaware River.

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

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on shortnose and Atlantic sturgeon. We have analyzed the available information, however, to consider likely impacts to sturgeon in the action area. We consider here, likely effects of climate change during the period from now until 2027, the duration of the effects from the proposed project (deepening and maintenance dredging).

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 Delaware River are not limited by any impassable falls or manmade barriers. Habitat that is suitable for spawning is known to be present upstream of the areas that are thought to be used by shortnose and Atlantic sturgeon suggesting that there may be some capacity for spawning to shift further upstream to remain ahead of the saltwedge. Based on predicted upriver shifts in the saltwedge, areas where Atlantic sturgeon currently spawn could, over time, become too saline to support spawning and rearing. Modeling conducted by the USACE indicates that this is unlikely to occur before 2040 but modeling conducted by Collier (2011) suggests that by 2100 areas where spawning is thought to occur (rkm 120-150 and 170-190), may be too salty and spawning would need to shift further north. Given the availability of spawning habitat in the river, it is unlikely that the saltwedge would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. The available habitat for juvenile sturgeon could decrease over time; however, even if the saltwedge shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon.

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 throughout the river. 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. 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 will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift to earlier in the year.

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.

Mean monthly ambient temperatures in the Delaware estuary range from 11-27°C from April – November, with temperatures lower than 11°C from December-March. No estimates of a predicted rise in water temperatures for the Delaware River are available. A predicted increase in water temperature of 3-4°C within 100 years is predicted in the Hudson River. If we assume that a similar rate of change would be experienced in the Delaware River, we would expect an increase of less than 1°C between now and 2027. This could 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.

6.5 Effects of Climate Change in the Action Area on Sea Turtles

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 sea turtles; however, we have analyzed the available information to consider likely impacts to these species in the action area. The proposed action under consideration will continue through 2027; thus, we consider here, likely effects of climate change during the period from now until 2027. Sea turtles are most likely to be affected by climate change due to increasing sand temperatures at nesting beaches which in turn would result in increased female:male sex ratio among hatchlings, sea level rise which could result in a reduction in available nesting beach habitat, increased risk of nest inundation, changes in the abundance and distribution of forage species which could result in changes in the foraging behavior and distribution of sea turtle species, and changes in water temperature which could possibly lead to a northward shift in their range.

Over the time period considered in this Opinion, sea surface temperatures are expected to rise less than 1°C. It is unknown if that is enough of a change to contribute to shifts in the range or distribution of sea turtles. Theoretically we expect that as waters in the action area warm, more sea turtles could be present or sea turtles could be present for longer periods of time. However, if temperature affected the distribution of sea turtle forage in a way that decreased forage in the action area, sea turtles may be less likely to occur in the action area. It has been speculated that the nesting range of some sea turtle species may shift northward. Nesting in the mid-Atlantic generally is extremely rare and no nesting has been documented at any beach in the action area. In 2010, one green sea turtle came up on the beach in Sea Isle City, New Jersey; however, it did not lay any eggs. In August 2011, a loggerhead came up on the beach in Stone Harbor, New Jersey but did not lay any eggs. On August 18, 2011, a green sea turtle laid one nest at Cape Henlopen Beach in Lewes Delaware near the entrance to Delaware Bay. The nest contained 190 eggs and was transported indoors to an incubation facility on October 7. A total of twelve eggs hatched, with eight hatchlings surviving. In December, seven of the hatchlings were released in Cape Hatteras, North Carolina. It is important to consider that in order for nesting to be successful in the mid-Atlantic, fall and winter temperatures need to be warm enough to support the successful rearing of eggs and sea temperatures must be warm enough for hatchlings to

survive when they enter the water. Predicted increases in water temperatures between now and 2027 are not great enough to allow successful rearing of sea turtle eggs in the action area. Therefore, it is unlikely that over the time period considered here, that there would be an increase in nesting activity in the action area or hatchlings would be present in the action area.

We have considered whether the disposal of sand at Broadkill Beach would impact sea turtles. As noted above, there is the potential for a northward shift in nesting by sea turtles. Given existing nesting locations and the relatively short duration of time considered in this Opinion (14 years), it seems extremely unlikely that the range of leatherback or Kemp's ridley sea turtle nesting would shift enough so that nesting would occur on beaches in Delaware Bay. The furthest north that leatherbacks nest is southeastern Florida. Kemp's ridleys only nest in Mexico. It is more likely that any shift in nesting to Delaware Bay beaches would be from loggerheads (which nest as far north as Virginia) and/or green sea turtles (which normally nest as far north as North Carolina). The disposal of material at Broadkill Beach is meant to stabilize and restore eroding habitats and maintain existing beach. None of the activity is likely to reduce the suitability of these beaches for potential future nesting.

7.0 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR § 402.02). 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). We have not identified any interdependent or interrelated actions. This Opinion examines the likely effects (direct and indirect) of the proposed action on shortnose sturgeon, five DPSs of Atlantic sturgeon, and sea turtles in the action area and their habitat within the context of the species status now and projected over the course of the action, the environmental baseline and cumulative effects. As explained in the "Description of the Action" section, the action under consideration in this Opinion is the ongoing initial dredging cycle needed to deepen the channel which will be conducted through January 2017, including deepening the channel to 50' in a 2.6 kilometer section of the Reedy Island range (within Reach D), the disposal of dredged material resulting from this dredging, including beneficial use of material at Broadkill Beach and Oakwood Beach, blasting of rock material at Marcus Hook and subsequent removal with a mechanical dredge, as well as maintenance dredging through 2027. The proposed action also includes a sturgeon relocation pilot project to be carried out in February and March 2014.

As explained in the "Description of the Action" section above, hydraulic cutterhead, hopper and mechanical dredges will be used for the initial deepening. Refer to Table 2 and Figure 1 in the "Description of the Action" section for a summary of the proposed dredging by reach. The effects of dredging on listed species will be different depending on the type of dredge used and the geographical area where dredging will occur. As such, the following discussion of effects of dredging will be organized by dredge type. Below, the discussion will consider the effects of dredging, including the risk of entrainment or capture of Atlantic sturgeon, shortnose sturgeon and sea turtles. We also consider effects of dredging and disposal on water quality, including

turbidity/suspended sediment and effects of dredge vessel traffic. Following, there is a discussion of blasting and associated debris removal with a mechanical dredge. Last, there is a discussion of other effects of the project which are not specific to the type of equipment used. This includes effects on prey and foraging and changes in the characteristics of the river (i.e., sediment type, location of the salt wedge). We also consider effects of maintenance dredging through 2027.

7.1 Hopper Dredge

Hopper dredges are self-propelled seagoing vessels that are equipped with propulsion machinery, sediment containers (hoppers), dredge pumps, and trailing suction drag-heads required to perform their essential function of excavating sediments from the channel bottom. Hopper dredges have propulsion power adequate for required free-running speed and dredge against strong currents. They also have excellent maneuverability. This allows hopper dredges to provide a safe working environment for crew and equipment dredging bar channels or other areas subject to rough seas. Hopper dredges also are more practicable when interference with vessel traffic must be minimized.

Dredged material is raised by dredge pumps through dragarms connected to drags in contact with the channel bottom and discharged into hoppers built in the vessel. Hopper dredges are equipped with large centrifugal pumps similar to those employed by other hydraulic dredges. Suction pipes (dragarms) are hinged on each side of the vessel with the intake (drag) extending downward toward the stern of the vessel. The drag is moved along the bottom as the vessel moves forward at speeds up to three mph (2.6 knots). The dredged material is sucked up the pipe and deposited and stored in the hoppers of the vessel.

A hopper dredge removes material from the bottom of the channel in relatively thin layers, usually 2-12 inches, depending upon the density and cohesiveness of the dredged material. Pumps located within the hull, but sometimes mounted on the drag arm, create a region of low pressure around the dragheads and force water and sediment up the drag arm and into the hopper. The more closely the draghead is maintained in contact with the sediment, the more efficient the dredging, provided sufficient water is available to slurry the sediments. Hopper dredges can efficiently dredge non-cohesive sands and cohesive silts and low density clay. Draghead types may consist of IHC and California type dragheads.

California type dragheads sit flatter in the sediment than the IHC configuration which is more upright. Individual draghead designs (i.e. dimensions, structural reinforcing/configuration) vary between dredging contractors and hopper vessels. Port openings on the bottom of dragheads also vary between contractors and draghead design. Generally speaking, the port geometry is typically rectangular or square with minimum openings of ten inch by ten inch or twelve inch by twelve inch or some rectangular variation.

Industry and government hopper dredges are equipped with various power and pump configurations and may differ in hopper capacity with different dredging capabilities. An engineering analysis of the known hydraulic characteristics of the pump and pipeline system on the USACE hopper dredge "Essayons" (a 6,423 cy hopper dredge) indicates an operational flow rate of forty cubic feet per second with a flow velocity of eleven feet per second at the draghead

port openings. The estimated force exerted on a one-foot diameter turtle (i.e. one foot diameter disc shaped object) at the pump operational point in this system was estimated to be twenty-eight pounds of suction or drag force on the object at the port opening of the draghead.

Dredging is typically parallel to the centerline or axis of the channel. Under certain conditions, a waffle or crisscross pattern may be utilized to minimize trenching or during clean-up dredging operations to remove ridges and produce a more level channel bottom. This movement up and down the channel while dredging is called trailing and may be accomplished at speeds of 1-3 knots, depending on the shoaling, sediment characteristics, sea conditions, and numerous other factors. In the hopper, the slurry mixture of the sediment and water is managed by a weir system to settle out the dredged material solids and overflow the supernatant water. When an economic load is achieved, the vessel suspends dredging, the drag arms are raised, and the dredge travels to the designated placement site. Because dredging stops during the trip to the placement site, the overall efficiency of the hopper dredge is dependent on the distance between the dredging location and placement sites; the more distance to the placement site, the less efficient the dredging operation resulting in longer contract periods to accomplish the work.

Sea turtle deflectors utilized on hopper dredges are rigid V-shaped attachments on the front of the dragheads and are designed and intended to plow the sediment in front of the draghead. The plowing action creates a sand wave that rolls in front of the deflector. The propagated sand wave is intended to shed a turtle away from the deflector and out of the path of the draghead. The effectiveness of the rigid deflector design and its ability to reduce entrainment was studied by the USACE through model and field testing during the 1980s and early 1990s (Nelson and Shafer 1996; Banks and Alexander 1994). The deflectors are most effective when operating on a uniform or flat bottom. The deflector effectiveness may be diminished when significant ridges and troughs are present that prevent the deflector from plowing and maintaining the sand wave and the dragheads from maintaining firm contact with the channel bottom.

7.1.1 Entrainment in Hopper Dredges – Sea Turtles

The remaining deepening will remove a total of 3,100,000 cy from Reach E (2,100,000 cy from lower Reach E and 1,000,000 cy from upper Reach E). Deepening began in lower Reach E (RM 20-5) in April 2015 and continued through August 2015. Deepening will resume in November 2015 and continue through April 2016, with disposal occurring on Broadkill Beach. Two dredges are working (RN Weeks and BE Lindholm) to complete the work. Approximately one million cy is scheduled to be removed from upper Reach E (RM 20-35) between April and December 2016 with disposal at the Artificial Island CDF. Maintenance of Reaches D and E, including removal of material for periodic nourishment of Oakwood Beach would involve removing approximately 33,000 cy of sand from Reach D every 8 years. Exact scheduling is dependent on funding and availability of dredge equipment. A hopper dredge may also be used for maintenance in other reaches of the river; however, no sea turtles occur upstream of Reach D so no sea turtles will be exposed to effects of hopper dredging carried out outside of Reach D or E.

7.1.1.1 Background Information on Entrainment of Sea Turtles in Hopper Dredges

As outlined above, sea turtles are likely to occur in Delaware Bay from May through mid-November each year with the largest numbers present from June through October of any year

(Stetzar 2002). The majority of sea turtles in the Delaware Estuary are juvenile loggerheads; however, adult loggerheads, juvenile Kemp's ridley, adult and juvenile leatherback and adult green sea turtles have also been documented in the area. The Delaware Estuary is an important foraging area for sea turtles and an important developmental habitat for juvenile sea turtles, particularly loggerheads. The only dredging operations that are scheduled to occur in the geographic region of the action area where sea turtles are likely to occur are deepening and maintenance in Reaches D and E.

Entrainment is defined as the direct uptake of aquatic organisms by the suction field generated at the draghead. Hydraulic dredges operate for prolonged periods underwater, with minimal disturbance, but generate continuous flow fields of suction forces while dredging. Loggerhead, Kemp's ridley and green sea turtles are vulnerable to entrainment in the draghead of the hopper dredge. Given their large size, leatherback sea turtles are not vulnerable to entrainment. As reported by USACE, no leatherback sea turtles have been entrained in hopper dredge operations operating along the U.S. Atlantic coast (USACE Sea Turtle Warehouse, 2012). The areas to be dredged in Reaches D and E are part of the summer developmental habitat of juvenile sea turtles and are used by turtles for foraging. Sea turtles are likely to be feeding on or near the bottom of the water column during the warmer months, with loggerhead and Kemp's ridley sea turtles being the most common species in these waters. Although not expected to be as numerous as loggerheads and Kemp's ridleys, green sea turtles are also likely to occur seasonally in Reach D and E.

Most sea turtles are able to escape from the oncoming draghead due to the slow speed that the draghead advances (up to 3 mph or 4.4 feet/second). Interactions with a hopper dredge result primarily from crushing when the draghead is placed on the bottom or when an animal is unable to escape from the suction of the dredge and becomes stuck on the draghead (impingement). Entrainment occurs when organisms are sucked through the draghead into the hopper. Mortality most often occurs when animals are sucked into the dredge draghead, pumped through the intake pipe and then killed as they cycle through the centrifugal pump and into the hopper.

Interactions with the draghead can also occur if the suction is turned on while the draghead is in the water column (i.e., not seated on the bottom). USACE implements procedures to minimize the operation of suction when the draghead is not properly seated on the bottom sediments which reduces the risk of these types of interactions.

Sea turtles may become entrained in hopper dredges as the draghead moves along the bottom. Because entrainment is believed to occur primarily while the draghead is operating on the bottom, it is likely that only those species feeding or resting on or near the bottom would be vulnerable to entrainment. Turtles can also be entrained if suction is created in the draghead by current flow while the device is being placed or removed, or if the dredge is operating on an uneven or rocky substrate and rises off the bottom. Recent information from USACE suggests that the risk of entrainment is highest when the bottom terrain is uneven or when the dredge is conducting "clean up" operations at the end of a dredge cycle when the bottom is trenched and the dredge is working to level out the bottom. In these instances, it is difficult for the dredge operator to keep the draghead buried in the sand and sea turtles near the bottom may be more

vulnerable to entrainment.

There is some evidence to indicate that turtles can become entrained in trunions or other water intakes (see Nelson and Shafer 1996). For example, a large piece of a loggerhead sea turtle was found in a UXO screening basket on Virginia Beach in 2013. The hopper dredge was operated with UXO screens on the draghead designed to prevent entrainment of any material with a diameter greater than 1.25". The pieces of turtle found were significantly larger. Because an inspection of the UXO screens revealed no damage, it is suspected that the sea turtle was entrained in another water intake port. There are also several examples of relatively large sturgeon (2-3' length) detected in inflow screening alive and relatively uninjured. Given the damage anticipated from passing through the pumps, it is possible that these sturgeon were entrained somewhere other than the draghead. USACE is currently investigating potential sources of entrainment and exploring the use of screening to minimize possible entrainment in areas other than the draghead.

Sea turtles have been killed in hopper dredge operations along the East and Gulf coasts of the US. Documented turtle mortalities during dredging operations in the USACE South Atlantic Division (SAD; i.e., south of the Virginia/North Carolina border) are more common than in the USACE North Atlantic Division (NAD; Virginia-Maine) presumably due to the greater abundance of turtles in these waters and the greater frequency of hopper dredge operations. For example, in the USACE SAD, over 480 sea turtles have been entrained in hopper dredges since 1980 and in the Gulf Region over 200 sea turtles have been killed since 1995. Records of sea turtle entrainment in the USACE NAD began in 1994. Through October 2015, 85 sea turtles deaths (see Table 12) related to hopper dredge activities have been recorded in waters north of the North Carolina/Virginia border (USACE Sea Turtle Database¹⁵); the majority of these turtles have been entrained in dredges operating in Chesapeake Bay.

Interactions are likely to be most numerous in areas where sea turtles are resting or foraging on the bottom. When sea turtles are at the surface, or within the water column, they are not likely to interact with the dredge because there is little, if any, suction force in the water column. Sea turtles have been found resting on the ocean bottom in deeper waters, which could increase the likelihood of interactions from dredging activities. In 1981, observers documented the take of 71 loggerheads by a hopper dredge at the Port Canaveral Ship Channel, Florida (Slay and Richardson 1988). This channel is a deep, low productivity environment in the Southeast Atlantic where sea turtles are known to rest on the bottom, making them extremely vulnerable to entrainment. The large number of turtle mortalities at the Port Canaveral Ship Channel in the early 1980s resulted in part from turtles being buried in the soft bottom mud, a behavior known as brumation. Since 1981, 77 loggerhead sea turtles have been taken by hopper dredge operations in the Port Canaveral Ship Channel, Florida. Chelonid turtles have been found to make use of deeper, less productive channels as resting areas that afford protection from predators because of the low energy, deep water conditions. Habitat in the action area is not consistent with areas

¹⁵ The USACE Sea Turtle Data Warehouse is maintained by the USACE's Environmental Laboratory and contains information on USACE dredging projects conducted since 1980 with a focus on information on interactions with sea turtles.

where sea turtle brumation has been documented; therefore, we do not anticipate any sea turtle brumation in the action area. Very few interactions with sea turtles have been recorded in Delaware Bay. This may be because the area where the dredge is operating is more wide-open providing more opportunities for escape from the dredge as compared to a narrow river or harbor entrance.

On a hopper dredge, it is possible to monitor entrainment because the dredged material is retained on the vessels as opposed to the direct placement of dredged material both overboard or in confined disposal facilities by a hydraulic pipeline dredge. A hopper dredge contains screened inflow cages from which an observer can inspect recently dredged contents. Typically, the observer inspection is performed at the completion of each load while the vessel is transiting to the authorized placement area and does not impact production of the dredging operations.

Before 1994, endangered species observers were not required on board hopper dredges and dredge baskets were not inspected for sea turtles or sea turtle parts. The majority of sea turtle takes in the NAD have occurred in the Norfolk district. This is largely a function of the large number of loggerhead and Kemp's ridley sea turtles that occur in the Chesapeake Bay each summer and the intense dredging operations that are conducted to maintain the Chesapeake Bay entrance channels and for beach nourishment projects at Virginia Beach. Since 1992, the take of 10 sea turtles (all loggerheads) has been recorded during hopper dredge operations in the Philadelphia, Baltimore and New York Districts. Hopper dredging is relatively rare in New England waters where sea turtles are known to occur, with most hopper dredge operations being completed by the specialized Government owned dredge Currituck which operates at low suction and has been demonstrated to have a very low likelihood of entraining or impinging sea turtles. To date, no hopper dredge operations (other than the Currituck) have occurred in the New England District in areas or at times when sea turtles are likely to be present.

Of the 10 sea turtle mortalities attributed to hopper dredge operations outside of the Norfolk District since 1992, 6 have occurred in the Philadelphia District, 3 in the Baltimore District and 1 in the New York District. As explained in the USACE BA, the Philadelphia District Endangered Species Monitoring Program began in 1992. For four hopper dredging projects conducted in 1992 – 1994, observers were present to provide approximately 25% coverage (6 hours on, 6 hours off on a biweekly basis). No sea turtles were observed during the 8/25-10/13/92 dredging at Bethany Bay, DE or the 10/24-11/14/92 dredging at Cape May, NJ. The dredge McFarland worked in the Delaware River entrance channel from 6/23 – 7/23/93 with no sea turtle observations. The dredge continued in the Brandywine Range from 7/24-8/2 and 8/10-8/19/93. Fresh sea turtle parts were observed in the inflow screening on two separate dates three days apart in the Brandywine Range of the Delaware Bay. Additionally, three live sea turtles were observed from the bridge during dredging operations. Dredging with the McFarland continued in the Delaware Bay entrance channel from 6/13-8/10/94. During this dredging cycle, relocation trawling was conducted in an attempt to capture sea turtles in the area where dredging was occurring and move them away from the dredge. Eight loggerhead sea turtles were captured alive with the trawl and relocated away from the dredging site. One loggerhead was taken by the dredge on June 22, 1994. Since this event in 1994, dredge observer coverage was increased to 50%. On November 3, 1995, one loggerhead was taken by a hopper dredge operating in the

entrance channel. In 1999, dredging occurred in July at the entrance channel. Three decomposed loggerheads were observed at Brandywine Shoal and Reedy Island by the dredge observer while the dredge was transiting to the disposal site. There is no evidence to suggest that these turtles were killed during dredging operations. On July 27, 2005 fresh loggerhead parts were observed in two different dredge loads while dredging was being conducted in the Miah Maull Range of the channel in Delaware Bay. It is currently unknown whether these were parts of the same turtle or two different turtles.

In addition to the sea turtles observed as entrained, one loggerhead was killed during dredging operations off Sea Girt, New Jersey during an USACE New York District beach renourishment project on August 23, 1997. This turtle was closed up in the hinge between the draghead and the dragarm as the dragarm lifted off the bottom.

Table 12: Sea Turtle Takes in USACE NAD Dredging Operations

Project Location	Year of Operation	Cubic Yardage Removed	Observed Takes
York Spit Channel	2015	1,747,000	5 loggerheads
Cape Henry Channel	2014	1,640,000	3 Loggerheads 1 Kemp's ridley
Sandbridge Shoal	2013	2,200,000	1 loggerhead ¹⁶
Cape Henry Channel	2012	1,190,004	1 loggerhead
York Spit	2012	145,332	1 Loggerhead
Thimble Shoal Channel	2009	473,900	3 Loggerheads
York Spit	2007	608,000	1 Kemp's Ridley
Cape Henry	2006	447,238	3 Loggerheads
Thimble Shoal Channel	2006	300,000	1 loggerhead
Delaware Bay	2005	50,000	2 Loggerheads
Thimble Shoal Channel	2003	1,828,312	7 Loggerheads 1 Kemp's ridley 1 unknown
Cape Henry	2002	1,407,814	7 Loggerheads 1 Kemp's ridley 1 green

¹⁶ Sea turtle observed in cage on beach (material pumped directly to beach from dredge)

York Spit Channel	2002	911,406	8 Loggerheads 1 Kemp's ridley
Cape Henry	2001	1,641,140	2 loggerheads 1 Kemp's ridley
VA Beach Hurricane Protection Project (Thimble Shoals)	2001	4,000,000	5 loggerheads 1 unknown
Thimble Shoal Channel	2000	831,761	2 loggerheads 1 unknown
York River Entrance Channel	1998	672,536	6 loggerheads
Atlantic Coast of NJ	1997	1,000,000	1 Loggerhead
Thimble Shoal Channel	1996	529,301	1 loggerhead
Delaware Bay	1995	218,151	1 Loggerhead
Cape Henry	1994	552,671	4 loggerheads 1 unknown
York Spit Channel	1994	61,299	4 loggerheads
Delaware Bay	1994	283,000	1 Loggerhead
Delaware Bay	1993	415,000	2 Loggerheads
Off Ocean City MD	1992	1,592,262	3 Loggerheads
			<i>TOTAL = 85 Turtles</i>

It should be noted that the observed takes may not be representative of all the turtles killed during dredge operations. Typically, endangered species observers are required to observe a total of 50% of the dredge activity (i.e., 8 hours on watch, 8 hours off watch). As such, if the observer was off watch or the cage was emptied and not inspected or the dredge company either did not report or was unable to identify the turtle incident, there is the possibility that a turtle could be taken by the dredge and go unnoticed. Additionally, in older Opinions (i.e., prior to 1995), we frequently only required 25% observer coverage and monitoring of the overflows which has since been determined to not be as effective as monitoring of the intakes. These conditions may have led to sea turtle takes going undetected.

We raised this issue to the USACE Norfolk District during the 2002 season, after several turtles were taken in the Cape Henry and York Spit Channels, and expressed the need for 100% observer coverage. On September 30, 2002, the USACE informed the dredge contractor that when the observer was not present, the cage should not be opened unless it is clogged. This modification was to ensure that any sea turtles that were taken and on the intake screen (or in the

cage area) would remain there until the observer evaluated the load. USACE's letter further stated "Crew members will only go into the cage and remove wood, rocks, and man-made debris; any aquatic biological material is left in the cage for the observer to document and clear out when they return on duty. In addition, the observer is the only one allowed to clean off the overflow screen. This practice provides us with 100% observation coverage and shall continue." Theoretically, all sea turtle parts were observed under this scheme, but the frequency of clogging in the cage is unknown at this time. The most effective way to ensure that 100% observer coverage is attained is to have a NMFS-approved endangered species observer monitoring all loads at all times. This level of observer coverage would document all turtle interactions and better quantify the impact of dredging on turtle populations.

It is likely that not all sea turtles killed by dredges are observed onboard the hopper dredge. Several sea turtles were stranded on Virginia shores with crushing type injuries from May 25 to October 15, 2002. The Virginia Marine Science Museum (VMSM) found 10 loggerheads, two Kemp's ridleys, and one leatherback exhibiting injuries and structural damage consistent with what they have seen in animals that were known dredge takes. While it cannot be conclusively determined that these strandings were the result of dredge interactions, the link is possible given the location of the strandings (e.g., in the southern Chesapeake Bay near ongoing dredging activity), the time of the documented strandings in relation to dredge operations, the lack of other ongoing activities which may have caused such damage, and the nature of the injuries (e.g., crushed or shattered carapaces and/or flipper bones, black mud in mouth). Additionally, in 1992, three dead sea turtles were found on an Ocean City, Maryland beach while dredging operations were ongoing at a borrow area located three miles offshore. Necropsy results indicate that the deaths of all three turtles were dredge related. It is unknown if turtles observed on the beach with these types of injuries were crushed by the dredge and subsequently stranded on shore or whether they were entrained in the dredge, entered the hopper and then were discharged onto the beach with the dredge spoils. A dredge could have crushed an animal as it was setting the draghead on the bottom, or if the draghead was lifting on and off the bottom due to uneven terrain, but the actual cause of these crushing injuries cannot be determined at this time. Further analyses need to be conducted to better understand the link between crushed strandings and dredging activities, and if those strandings need to be factored into an incidental take level. Regardless, it is possible that dredges are taking animals that are not observed on the dredge which may result in strandings on nearby beaches.

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 as noted above in the examples of sea turtle takes. Dredging operations may go on for months, with sea turtle takes occurring intermittently throughout the duration of the action. For example, dredging occurred at Cape Henry over 160 days in 2002 with 8 sea turtle takes occurring over three separate weeks while dredging at York Spit in 1994 resulted in four sea turtle takes in one week. In Delaware Bay, dredge cycles have been conducted during the May-November period with no observed entrainment and as many as two sea turtles have been entrained in as little as three weeks. Even in locations where thousands of sea turtles are known to be present (i.e., Chesapeake Bay) and where dredges are operating in

areas with preferred sea turtle depths and forage items (as evidenced by entrainment of these species in the dredge), the numbers of sea turtles entrained is an extremely small percentage of the likely number of sea turtles in the action area. This is likely due to the distribution of individuals throughout the action area, the relatively small area which is affected at any given moment and the ability of some sea turtles to avoid the dredge even if they are in the immediate area.

The number of interactions between dredge equipment and sea turtles seems to be best associated with the volume of material removed, which is closely correlated to the length of time dredging takes, with a greater number of interactions associated with a greater volume of material removed and a longer duration of dredging. The number of interactions is also heavily influenced by the time of year dredging occurs (with more interactions correlated to times of year when more sea turtles are present in the action area) and the type of dredge plant used (sea turtles are apparently capable of avoiding pipeline and mechanical dredges as no takes of sea turtles have been reported with these types of dredges). The number of interactions may also be influenced by the terrain in the area being dredged, with interactions more likely when the draghead is moving up and off the bottom frequently. Interactions are also more likely at times and in areas when sea turtle forage items are concentrated in the area being dredged, as sea turtles are more likely to be spending time on the bottom while foraging.

As explained above, since 1992 endangered species observers have worked on all hopper dredge operations below the Delaware Memorial Bridge operating between June and November. Prior to 1995, observers worked one week on, one week off, resulting in approximately 25% observer coverage. Since 1995, observers have provided continuous 8-hour on 8-hour off coverage. Cages are generally not cleaned without the observer being present, so it is likely that greater than 50% of material has been observed and that the number of entrainments that go undetected is low. Therefore, while observers are only on watch for 50% of dredge operations, the requirement that cages not be cleaned by anyone other than the observer and that the observer be brought on deck if a turtle is observed while the observer is off-watch, results in a much higher percentage of cover. Six sea turtles have been entrained in hopper dredges operating in Delaware Bay since 1993. As sea turtles have been documented in the action area and suitable habitat and forage items are present, it is likely that sea turtles will be present in the action area when dredging takes place.

We have compiled a dataset representing all of the hopper dredge projects in the Philadelphia District that have reported the cubic yardage removed as well as the number of takes observed. Records for 12 projects occurring during “sea turtle season” (i.e., May – November 15) in the Philadelphia District are available that report the cubic yardage removed during a project. Of these, seven projects involved dredging in the Philadelphia to the Sea navigation channel and five involved dredging off the Atlantic coast of Delaware. The distribution of sea turtles in offshore locations such as offshore borrow areas used for beach nourishment is not expected to be comparable to the distribution of sea turtles in estuarine foraging areas such as Delaware Bay. Additionally, as evidenced in the sea turtle database, very few sea turtles have been entrained in hopper dredges operating at any offshore borrow area. This is true even in the southeast, where large numbers of sea turtles are present year round. This is likely due to the transitory nature of

most sea turtles occurring in offshore borrow areas as well as the widely distributed nature of sea turtles in offshore waters. As such, we have excluded the five projects involving dredging off the Atlantic coast of Delaware from the dataset used to estimate an entrainment rate for sea turtles in hopper dredges operating in Delaware Bay (see Table 13 below).

As explained above, for projects prior to 1995, observers were only present on the dredge for every other week of dredging. For dredging undertaken since 1995, observers were present on board the dredge full time and worked an 8-hour on, 8-hour off shift. The only time that cages (where sea turtle parts are typically observed) were cleaned by anyone other than the observer was when there was a clog. If a turtle or turtle part was observed in such an instance, crew were instructed to inform the observer, even if off-duty. As such, it is reasonable to expect that even though the observer was on duty for only 50% of dredge hours, an extremely small amount of biological material went unobserved. To make the data from the 1993 and 1994 dredge events when observers were only on board every other week, comparable to the 1995-2006 data when observers were on board full time, we have assumed that an equal number of turtles were entrained when observers were not present. This calculation is reflected in Table 13 as “adjusted entrainment number.”

Table 13: Sea turtle entrainment in Philadelphia District dredging operations

Project	Dates	CY Removed	Observed Entrainment	Adjusted Entrainment Number
Philadelphia to the Sea – Contract 4 Deepening of Reach D	February – June 2013	1,149,946	0	0
Philadelphia to the Sea – Miah Maull, Brandywine, Deepwater and Liston ranges	08/08/06 - 08/23/06; 09/07/06 - 11/16/06	390,000	0	0
Philadelphia to the Sea – Brandywine and Deepwater Ranges	11/01/2005 - 11/18/2005	167,982	0	0
Philadelphia to the Sea – Miah Maull and Brandwine	10/04/05 - 10/22/2005	162,682	0	0
Philadelphia to the Sea 40’ Maintenance	2004	50,000	0	0
Philadelphia to the Sea 40’ Maintenance	2002	50,000	0	0
Philadelphia to the Sea 40’ Maintenance	2001	50,000	0	0

Philadelphia to the Sea – Miah Maull	7/24/05 - 7/27/05	50,000	2	2
Philadelphia to the Sea – Miah Maull and Brandywine	10/07/95 -11/16/95	218,151	1	1
Philadelphia to the Sea – Miah Maul	McFarland 6/15/94-8/10/94	2,830,000	1	2
Cape May Inlet Beachfill – Brandywine Range	07/24/93 - 08/19/93	415,000	2	4
TOTAL		5,533,761	6	9

7.1.1.2 Predicted Entrainment in Proposed Hopper Dredging

Based on the data in Table 13, we have made calculations which indicate that an average of one sea turtle is killed for approximately every 600,000 cy removed¹⁷. This calculation has been based on a number of assumptions including the following: that sea turtles are evenly distributed throughout all channel reaches for which takes have occurred, that all dredges will take an identical number of sea turtles, and that sea turtles are equally likely to be encountered throughout the May to November time frame. Based on these calculations, we expect that for dredging in Reaches D and E of the navigation channel during the time of year when sea turtles are likely to be present, one sea turtle is likely to be entrained for every 600,000 cubic yards of material removed by a hopper dredge. While this estimate is based on several assumptions, it is reasonable because it uses the best available information on entrainment of sea turtles from past dredging operations in the action area, including channel reaches that are contained within Reaches D and E, and includes multiple projects over several years, all of which have had observer coverage.

With the exception of one green turtle entrained in a hopper dredge operating in Chesapeake Bay, all other sea turtles entrained in dredges operating in the USACE NAD have been loggerheads and Kemp’s ridley. Of these 85 sea turtles, 74 have been loggerheads, 6 have been Kemp’s ridleys, 1 green and 4 unknown. Overall, of those identified to species, approximately 91% of the sea turtles entrained in dredges operating in the USACE North Atlantic Division have been loggerheads. No Kemp’s ridleys or greens have been entrained in dredge operations outside of the Chesapeake Bay area. The high percentage of loggerheads is likely due to several factors including their tendency to forage on the bottom where the dredge is operating and the fact that this species is the most numerous of the sea turtle species in Northeast and Mid-Atlantic waters. It is likely that the documentation of only one green sea turtle entrainment in Virginia dredging operations is a reflection of the low numbers of green sea turtles that occur in waters north of North Carolina. The low number of green sea turtles in the action area makes an interaction with a green sea turtle extremely unlikely to occur.

¹⁷ This is calculated by dividing the total number of cy of material removed (5,533,761) by the adjusted number of sea turtle entrainments (9). This results in 1 sea turtle per 614,862 cy removed in Delaware Bay.

Based on the above information, it is reasonable to expect that one sea turtle is likely to be injured or killed for approximately every 600,000 cy of material removed from Reach D and E between May and November, and that at least 90% will be loggerheads. Deepening of Reach D is complete. Work in lower Reach E occurred from April to August 2015 and will recommence in November 2015 to continue through April 2016. We do not expect any interactions with sea turtles between December 2015 and March 2016. Approximately 1,000,000 cy of material remains to be removed from lower reach E. Assuming that removal rates are equal month to month, we would expect approximately 167,000 cy of material to be removed each month. This means that less than 400,000 cy of material will be removed in November 2015 and April 2016 when sea turtles could be present in the Bay. As such, we anticipate no more than one sea turtle will be entrained during the remaining deepening of lower Reach E. Nearly all of the deepening of upper Reach E will occur when sea turtles are present in the Bay. Using the entrainment rate discussed above, we expect no more than two sea turtles will be entrained during deepening of upper Reach E. Based on the information outlined above and the volume of material estimated to be removed, we anticipate the following entrainment:

Table 14: Expected Sea Turtle Entrainment during Hopper Dredging for Deepening

Reach	Scheduled Dates	Total Volume	Expected Sea turtle interactions
Lower Reach E (Broadkill Beach)	November 2015 – April 2016	<400,000 outside of December-March	1
Upper Reach E (Artificial Island CDF)	April – December 2016	1,000,000	2
		Total:	3

As such, we anticipate that no more than three sea turtles are likely to be entrained during the remaining of the deepening. We expect that nearly all of the sea turtles will be loggerheads and that the entrainment of a Kemp’s ridley during a particular dredge cycle will be rare; however, as Kemp’s ridleys have been documented in the action area and have been entrained in hopper dredges, it is likely that this species will interact with the dredge over the course of the project life. As explained above, approximately 91% of the sea turtles taken in dredges operating in the USACE North Atlantic Division have been loggerheads and all sea turtles entrained in hopper dredges operating in Delaware Bay have been loggerheads. Based on the ratio of sea turtle entrainment in the USACE NAD, no more than one of the sea turtles likely to be entrained in a hopper dredge will be a Kemp’s ridley, with the remainder being loggerheads. As noted above, interactions with green sea turtles are extremely unlikely, and we do not expect any to occur.

USACE has indicated that, on average, approximately 472,000 cubic yards of material will be removed from Reaches D and E (collectively) each year in order to maintain the 45 foot channel. Dredging will not occur within this entire area each year, but would only occur in any areas where shoaling created a navigational hazard. Additionally, 33,000 cy of material will be

removed once every 8 years for placement on Oakwood Beach. As explained above, we have estimated an entrainment rate for sea turtles in hopper dredges operating in Reaches D and E of the Philadelphia to the Sea project as one sea turtle per every 600,000 cubic yards of material removed during the time of year when sea turtles are likely to be present (i.e., May – November 15).

Provided that maintenance occurs during the May – November window when sea turtles are likely to be present and that it occurs with a hopper dredge, no more than one sea turtle is likely to be entrained for each 600,000 cy of material removed. USACE anticipates the annual removal of approximately 472,000 cy of material from Reach D and E once deepening is completed. Deepening in Reach D was completed in 2013. Deepening in Reach E will be completed in 2016. Between now and 2027, we anticipate 12 annual maintenance events in Reach D and E plus one event to remove material for Oakwood Beach, for a total of approximately 5.7 million cy of material removed during maintenance operations through 2027. We anticipate the entrainment of 10 sea turtles over that time period, with 90% being loggerheads (9) and the remainder being Kemp's ridley (1).

7.1.2 Entrainment in Hopper Dredges – Sturgeon

Sturgeon are vulnerable to entrainment in hopper dredges. Entrainment is believed to occur primarily when the draghead is not in firm contact with the channel bottom, so the potential exists that sturgeon feeding or resting on or near the bottom may be vulnerable to entrainment. Additionally, the size and flow rates produced by the suction power of the dredge, the condition of the channel being dredged, and the method of operation of the dredge and draghead all relate to the potential of the dredge to entrain sturgeon (Reine and Clarke 1998). These parameters also govern the ability of the dredge to entrain other species of fish, sea turtles, and shellfish.

The risk of interactions is related to both the amount of time sturgeon spend on the bottom and the behavior the fish are engaged in (i.e., whether the fish are overwintering, foraging, resting or migrating) as well as the intake velocity and swimming abilities of sturgeon in the area (Clarke 2011). Intake velocities at a typical large self-propelled hopper dredge are 11 feet per second. As noted above, exposure to the suction of the draghead intake is minimized by not turning on the suction until the draghead is properly seated on the bottom sediments and by maintaining contact between the draghead and the bottom.

A significant factor influencing potential entrainment is based upon the swimming stamina and size of the individual fish at risk (Boysen and Hoover, 2009). Swimming stamina is positively correlated with total fish length. Entrainment of larger sturgeon is less likely due to the increased swimming performance and the relatively small size of the draghead opening. Juvenile entrainment is possible depending on the location of the dredging operations and the time of year in which the dredging occurs. Typically, major concerns of juvenile entrainment relate to fish below 200 mm (Hoover *et al.*, 2005; Boysen and Hoover, 2009). Juvenile sturgeon are not as powerful swimmers as older, larger fish and they are prone to bottom-holding behaviors, which make them more vulnerable to entrainment when in close proximity to dragheads (Hoover *et al.*, 2011). Intake velocities at a typical large self-propelled hopper dredge are 11 feet per second.

In general, entrainment of large mobile animals, such as sturgeon, is relatively rare. Several factors are thought to contribute to the likelihood of entrainment. In areas where animals are present in high density, the risk of an interaction is greater because more animals are exposed to the potential for entrainment. The risk of entrainment is likely to be higher in areas where the movements of animals are restricted (e.g., in narrow rivers or confined bays) where there is limited opportunity for animals to move away from the dredge than in unconfined areas such as wide rivers or open bays. The hopper dredge draghead operates on the bottom and is typically at least partially buried in the sediment. Sturgeon are benthic feeders and are often found at or near the bottom while foraging or while moving within rivers. Sturgeon at or near the bottom could be vulnerable to entrainment if they were unable to swim away from the draghead.

Entrainment of sturgeon during hopper dredging operations in Federal navigation channels appears to be relatively rare. From 1990-2012, USACE documented 28 incidents of sturgeon entrainment on monitored hopper dredges (see Appendix A). Of these, 20 were Atlantic sturgeon, five were shortnose and two were Gulf sturgeon (one unknown). Since that report was generated, one Atlantic sturgeon was entrained in the Ambrose Channel, New York (October 2012; alive); one Atlantic sturgeon was entrained in the Delaware River in May 2013 (released alive); and five sturgeon were entrained in the Delaware River by hopper dredges in 2014. Four of these occurred during maintenance of the 40' Philadelphia to the Sea channel in areas that had not been deepened (May – dead juvenile Atlantic; August – dead adult Atlantic; September – dead juvenile Atlantic; October – dead juvenile Atlantic). One of the five (November – live juvenile Atlantic) occurred during maintenance of the 45' channel. Additionally, part of a decomposed sturgeon was entrained in a hopper dredge in the Delaware River in September 2013. Additional details on these interactions are presented in the table below. With the exception of the adult entrained in August 2014¹⁸, all recorded interactions with sturgeon have been with juveniles or subadults (length <150 cm). Given the large size of adults (greater than 150cm) and the size of the openings on the dragheads used for this action (openings no greater than 4" x 4"), adult Atlantic sturgeon are unlikely to be vulnerable to entrainment.

As explained above, since 1992, endangered species observers have been present for at least a portion of all hopper dredging done during the June – November time frame below the Delaware Memorial Bridge (i.e., Reaches D and E); no sturgeon have been observed during dredging activities in Reaches D or E, including deepening that occurred in Reach E from April to August 2015. Observers have been placed on hopper dredges operating in Reaches AA and A since 2012. To date, seven sturgeon interactions have been recorded including the entrainment of a decomposed sturgeon in 2013.

¹⁸ The draghead operating on August 31, 2014 in the Philadelphia to Trenton reach had 10" x 10" openings.

Table 15: Sturgeon takes from hopper dredging in Delaware River since 2012

Date	Species	Size (cm)	Condition	Dredging Activity
May 11, 2013	Atlantic	43	Live	Maintenance of 45' Philadelphia to Sea channel (Reach AA)
May 16, 2014	Atlantic	41	Dead	Maintenance of 40' Philadelphia to Sea channel (Reach B)
August 31, 2014	Atlantic	181	Dead	Maintenance of 40' Philadelphia to Trenton channel
Sept. 1, 2014	Atlantic	46	Dead	Maintenance of 40' Philadelphia to Trenton channel
Oct. 24, 2014	Atlantic	29	Dead	Maintenance of 45' Philadelphia to Sea channel (Reach A)
Nov. 26, 2014	Atlantic	31	Live	Maintenance of 45' Philadelphia to Sea channel (Reach A)

As described in the discussion of sea turtles above, many other hopper dredge projects have occurred in NMFS Greater Atlantic Region; nearly all of which overlap with times and areas where Atlantic or shortnose sturgeon are known to be present. Because observers have been present on these dredges and interactions with sturgeon are required to be reported to us, any interactions with Atlantic sturgeon would have been reported to us. A total of 15 sturgeon (five shortnose, all in the Kennebec River; and 10 Atlantics: two in York Spit, VA, one in Sandy Hook, NJ, one in Ambrose Channel, NY and six in Delaware River), have been observed as entrained in hopper dredges in the GAR, with six occurring in the Delaware River and four of those in the action area.

7.1.2.1 Anticipated Entrainment of Shortnose and Atlantic sturgeon in Hopper Dredges During Remaining Deepening Contracts

As explained above, since 1992, endangered species observers have been present for at least a portion of all hopper dredging done during the June – November time frame below the Delaware Memorial Bridge (i.e., Reaches D and E). No shortnose or Atlantic sturgeon have been documented during hopper dredge activities in Reaches D and E in the Philadelphia to the Sea channel maintenance. Deepening of Reach D was completed in 2013; over 2 million cy of material was removed and no sturgeon were observed. Deepening of Reach E began in April 2015, work completed through August 2015 resulted in the removal of approximately 900,000 cy of material with two dredges. No sturgeon were observed. Work will resume in November 2015 and continue through April 2016 in lower Reach E, with the removal of approximately 2.1 million cy anticipated. Approximately 1 million cy of material will be removed from upper Reach E between April and December 2016.

Atlantic and shortnose sturgeon are known to occur in Reach D and E. However, because observers have been used for dredging at Reach D and E in the past and no entrainment of sturgeon has been observed, we do not anticipate any future entrainment of Atlantic or shortnose

sturgeon in these reaches. The reduced risk of entrainment in these reaches is likely due to the width of the River and Bay in these areas, the known use of areas outside the channel rather than in the channel (O'Herron 1985), and the increased availability of habitat outside of the area where dredging is occurring which may increase the potential for sturgeon to escape from the dredge. Based on this information and the lack of interactions with shortnose sturgeon during dredging in this area in the past, no shortnose or Atlantic sturgeon are likely to be injured or killed during hopper dredging operations at these reaches.

7.1.2.2 Anticipated Entrainment of Shortnose and Atlantic sturgeon during maintenance of the deepened channel with a hopper dredge

The proposed action includes dredging necessary to maintain the channel at 45 feet once deepening has been completed. The proposed action under consideration in this consultation includes maintenance dredging through 2027.

As explained above, it is extremely unlikely that any shortnose or Atlantic sturgeon will be entrained by a hopper dredge operating in Reaches D or E. As such, no sturgeon are likely to be entrained during maintenance dredging operations in these reaches.

Delaware River – Reaches AA, A, B, and C

Maintenance dredging will also occur in the river (i.e., Reaches AA, A, B and C). USACE has indicated that annually on average, approximately 3,845,000 cy of material will be removed from these reaches. According to information provided by USACE, maintenance dredging of the deepened channel will occur between August 1 and March 15. A USACE cutterhead dredge is planned for use for all maintenance dredging activities. However, in some years, a hopper or mechanical dredge may be used depending on dredge availability and substrate type to be removed.

Based on the most recent sturgeon takes resulting from the Philadelphia to the Sea maintenance dredging project in 2014 (see Table 15), we have calculated an entrainment/capture rate of two sturgeon per year of maintenance dredging (when a hopper dredge is used). As we do not know the relative proportion of Atlantic and shortnose sturgeon in these reaches of the Delaware River, we cannot reliably predict the ratio of shortnose and Atlantics that may be entrained as a result of hopper dredging maintenance activities. Maintenance dredging is expected to occur annually as deepening in each reach is completed. Therefore, between now and 2027, we anticipate the entrainment of 24 sturgeon at an average rate of two per year (i.e., a maximum of 24 Atlantic sturgeon, 24 shortnose sturgeon, or any combination of the two species totaling 24 sturgeon). Using mixed stock analysis explained above, we have determined that Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. Given these percentages, we expect that of the maximum number of 24 Atlantic sturgeon that may be killed during maintenance dredging, 14 will originate from the New York Bight DPS, four from the Chesapeake Bay DPS, four from the South Atlantic DPS and two from the Gulf of Maine DPS. Given the low numbers of Carolina DPS fish in the action area and the low number of mortalities anticipated, it is unlikely that there will be any mortality of any Carolina DPS Atlantic sturgeon.

Given the size of screening on the dragheads (4" x 4"), we do not expect any entrainment of adult Atlantic sturgeon. We only expect interactions with juvenile or subadult Atlantic sturgeon. Interactions with shortnose sturgeon could include juveniles, subadults or adults.

There is evidence that some sturgeon, particularly juveniles and small subadults, could be entrained in the dredge and survive. However, as the extent of internal injuries and the likelihood of survival is unknown, and the size of the fish likely to be entrained is impossible to predict, it is reasonable to conclude that any sturgeon entrained in the hopper dredge is likely to be killed.

7.1.3 Interactions with the Sediment Plume- Hopper Dredge

Dredging operations cause sediment to be suspended in the water column. This results in a sediment plume in the water, 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. The nature, degree, and extent of sediment suspension around a dredging operation are controlled by many factors including : the particle size distribution, solids concentration, and composition of the dredged material; the dredge type and size, discharge/cutter configuration, discharge rate, and solids concentration of the slurry; operational procedures used; and the characteristics of the hydraulic regime in the vicinity of the operation, including water composition, temperature and hydrodynamic forces (i.e., waves, currents, etc.) causing vertical and horizontal mixing (USACE 1983).

Resuspension of fine-grained dredged material during hopper dredging operations is caused by the dragheads as they are pulled through the sediment, turbulence generated by the vessel and its prop wash, and overflow of turbid water during hopper filling operations. During the filling operation, dredged material slurry is often pumped into the hoppers after they have been filled with slurry in order to maximize the amount of solid material in the hopper. The lower density, turbid water at the surface of the filled hoppers overflows and is usually discharged through ports located near the waterline of the dredge. Use of this "overflow" technique results in a larger sediment plume than if no overflow is used. In 2001, a study was done of overflow and nonoverflow hopper dredging. Monitoring of the sediment plumes was accomplished using a boat-mounted 1,200-kHz Broad-Band Acoustic Doppler Current Profiler (ADCP). The instrument collects velocity vectors in the water column together with backscatter levels to determine the position and relative intensity of the sediment plume. Along with the ADCP, a MicroLite recording instrument with an Optical Backscatterance (OBS) Sensor was towed by the vessel at a depth of 15 ft. The MicroLite recorded data at 0.5-sec intervals. Navigation data for monitoring were obtained by a Starlink differential Global Positioning System (GPS). The GPS monitors the boat position from the starting and ending points along each transect.

Transects were monitored in the test area to obtain the background levels of suspended materials prior to dredging activities. A period of eight minutes following the dredge passing during non-overflow dredging showed the level of suspended material to be returning to background levels. No lateral dispersion of the plume out of the channel was observed during the non-overflow dredging operation. During overflow dredging, a wider transect was performed to determine the lateral extent of the plume. At one-hr elapsed time following the end of the overflow dredging operation, the levels of suspended material returned to background conditions. Again, no lateral

dispersion of the plume out of the channel area was observed. Overflow dredging is not proposed during deepening or maintenance dredging operations.

No information is available on the effects of total suspended solids (TSS) on juvenile and adult sea turtles. 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). TSS is most likely to affect sea turtles if a plume causes a barrier to normal behaviors or if sediment settles on the bottom affecting sea turtle prey. As sea turtles are highly mobile, they are likely to be able to avoid any sediment plume and any effect on sea turtle and sturgeon movements is likely to be insignificant. While an increase in suspended sediments may cause sea turtles to alter their normal movements, any change in behavior is likely to be insignificant as it will only involve movement to alter course out of the sediment plume, which is expected to be limited to the navigation channel and be present at any location for no more than eight minutes. Based on this information, any increase in suspended sediment will have no measurable effect on the movement of sea turtles between foraging areas or while migrating or otherwise adversely affect listed species in the action area.

The life stages of sturgeon most vulnerable to increased sediment are eggs and non-mobile larvae which are subject to burial and suffocation. As noted above, no shortnose sturgeon eggs and/or larvae will be present in the action area. Reach A partially overlaps with one of the areas where Atlantic sturgeon are thought to spawn. Dredging is scheduled to begin in this reaches in August. At that time of year, Atlantic sturgeon spawned that year (April/May) would be at least two-three months old and would be mobile; these fish are no longer considered larvae, but are YOY (see Table 5 in Section 4.7 above). All sturgeon in the action area at this time of year would be sufficiently mobile to avoid any sediment plume. Therefore, any shortnose and Atlantic sturgeon in the action area during dredging would be capable of avoiding any sediment plume by swimming around it. Laboratory studies (Niklitschek 2001 and Secor and Niklitschek 2001) have demonstrated shortnose and Atlantic sturgeon are able to actively avoid areas with unfavorable water quality conditions and that they will seek out more favorable conditions when available. While the increase in suspended sediments may cause sturgeon to alter their normal movements, any change in behavior is likely to be insignificant as it will only involve movement further up in the water column, or movement no more than a few hundred feet to an area just outside of the navigation channel. Based on this information, any increase in suspended sediment is not likely to affect the movement of shortnose or Atlantic sturgeon between foraging areas and/or concentration areas during any phase of dredging or otherwise negatively affect shortnose sturgeon in the action area.

7.2 Hydraulic Cutterhead Dredge

7.2.1 Available Information on the Risk of Entrainment of Sturgeon in Cutterhead Dredge

Maintenance of the existing 40 foot channel occurs routinely with some dredging accomplished with a cutterhead dredge. The cutterhead dredge operates with the dredge head buried in the sediment; however, a flow field is produced by the suction of the operating dredge head. The amount of suction produced is dependent on linear flow rates inside the pipe and the pipe diameter (Clausner and Jones 2004). High flow rates and larger pipes create greater suction

velocities and wider flow fields. The suction produced decreases exponentially with distance from the dredge head (Boysen and Hoover 2009). A cutterhead dredge is also used in the upriver Philadelphia to Trenton navigation channel. With a cutterhead dredge, material is pumped directly from the dredged area to a disposal site. As such, there is no opportunity to monitor for biological material on board the dredge; rather, observers work at the disposal site to inspect material.

It is generally assumed that sturgeon are mobile enough to avoid the suction of an oncoming cutterhead dredge and that any sturgeon in the vicinity of such an operation would be able to avoid the intake and escape. However, in mid-March 1996, two shortnose sturgeon were found in a dredge discharge pool on Money Island, near Newbold Island. The dead sturgeon were found on the side of the spill area into which the hydraulic pipeline dredge was pumping. An assessment of the condition of the fish indicated that the fish were likely alive and in good condition prior to entrainment and that they were both adult females. The area where dredging was occurring was a known overwintering area for shortnose sturgeon and large numbers of shortnose sturgeon were known to be concentrated in the general area. A total of 509,946 cy were dredged between Florence and the upper end of Newbold Island during this dredge cycle. Since that time, dredging occurring in the winter months in the Newbold – Kinkora range require that inspectors conduct daily inspections of the dredge spoil area in an attempt to detect the presence of any sturgeon. In January 1998, three shortnose sturgeon carcasses were discovered in the Money Island Disposal Area. The sturgeon were found on three separate dates: January 6, January 12, and January 13. Dredging was being conducted in the Kinkora and Florence ranges at this time which also overlaps with the shortnose sturgeon overwintering area. A total of 512,923 cy of material was dredged between Florence and upper Newbold Island during that dredge cycle. While it is possible that not all shortnose sturgeon killed during dredging operations were observed at the dredge disposal pool, USACE has indicated that due to flow patterns in the pool, it is expected that all large material (i.e., sturgeon, logs etc.) will move towards the edges of the pool and be readily observable. Deepening has occurred in Reach C, Reach B and Reach A. Dredging in Reach C occurred from March – September 2010 with 3,594,963 cy of material removed with a cutterhead dredge. Dredging in Reach B occurred in November and December 2011, with 1,100,000 cy of material removed with a cutterhead dredge. Dredging in Reach A occurred from September – February 2013 with the removal of approximately 1.2 million cy of material with a cutterhead dredge. In all cases, the dredge disposal area was inspected daily for the presence of sturgeon. No sturgeon were detected.

In an attempt to understand the behavior of sturgeon while dredging is ongoing, the USACE worked with sturgeon researchers to track the movements of tagged Atlantic and shortnose sturgeon while cutterhead dredge operations were ongoing in Reach B (ERC 2011). The movements of acoustically tagged sturgeon were monitored using both passive and active methods. Passive monitoring was performed using 14 VEMCO VR2 and VR2W single-channel receivers, deployed through the study area. These receivers are part of a network that was established and cooperatively maintained by Environmental Research and Consulting, Inc. (ERC), Delaware State University (DSU), and the Delaware Department of Natural Resources and Environmental Control (DNREC). Nineteen tagged Atlantic sturgeon and three tagged shortnose sturgeon (all juveniles) were in the study area during the time dredging was ongoing.

Eleven of the 19 juvenile Atlantic sturgeon detected during this study remained upriver of the dredging area and showed high fidelity to the Marcus Hook anchorage. Three of the juvenile sturgeon detected during this study (Atlantic sturgeons 13417, 1769; shortnose sturgeon 58626) appeared to have moved through Reach B when the dredge was working. The patterns and rates of movement of these fish indicated nothing to suggest that their behavior was affected by dredge operation. The other sturgeon that were detected in the lower portion of the study area either moved through the area before or after the dredging period (Atlantic sturgeons 2053, 2054), moved through Reach B when the dredge was shut down (Atlantic sturgeons 1774, 58628, 58629), or moved through the channel on the east side of Cherry Island Flats (shortnose sturgeon 2090, Atlantic sturgeon 2091) opposite the main navigation channel. It is unknown whether some of these fish chose behaviors (routes or timing of movement) that kept them from the immediate vicinity of the operating dredge. In the report, Brundage speculates that this could be to avoid the noisy area near the dredge but also states that on the other hand, the movements of the sturgeon reported here relative to dredge operation could simply have been coincidence.

A similar study was carried out in the James River (Virginia) (Cameron 2012). Dredging occurred with a cutterhead dredge between January 30 and February 19, 2009 with 166,545 cy of material removed over 417.6 hours of active dredge time. Six subadult Atlantic sturgeon (77.5 – 100 cm length) were caught, tagged with passive and active acoustic tags, and released at the dredge site. The study concluded that: tagged fish showed no signs of impeded up- or downriver movement due to the physical presence of the dredge; fish were actively tracked freely moving past the dredge during full production mode; fish showed no signs of avoidance response (e.g., due to noise generated by the dredge) as indicated by the amount of time spent in close proximity to the dredge after release (3.5 – 21.5 hours); and, tagged fish showed no evidence of attraction to the dredge.

Several scientific studies have been undertaken to understand the ability of sturgeon to avoid cutterhead dredges. Hoover *et al.* (2011) demonstrated the swimming performance of juvenile lake sturgeon and pallid sturgeon (12 – 17.3 cm FL) in laboratory evaluations. The authors compared swimming behaviors and abilities in water velocities ranging from 10 to 90 cm/second (0.33-3.0 feet per second). At distances more than 1.5 meters from the dredges, water velocities were negligible (10 cm/s). The authors conclude that in order for a sturgeon to be entrained in a dredge, the fish would need to be almost on top of the drag head and be unaffected by associated disturbance (e.g., turbidity and noise). The authors also conclude that juvenile sturgeon are only at risk of entrainment in a cutterhead dredge if they are in close proximity, less than 1 meter, to the drag heads.

Boysen and Hoover (2009) assessed the probability of entrainment of juvenile white sturgeon by evaluating swimming performance of young of the year fish (8-10 cm TL). The authors determined that within 1.0 meter of an operating dredge head, all fish would escape when the pipe was 61 cm (2 feet) or smaller. Fish larger than 9.3 cm (about 4 inches) would be able to avoid the intake when the pipe was as large as 66 cm (2.2 feet). The authors concluded that regardless of fish size or pipe size, fish are only at risk of entrainment within a radius of 1.5 – 2 meters of the dredge head; beyond that distance velocities decrease to less than 1 foot per second.

Clarke (2011) reports that a cutterhead dredge with a suction pipe diameter of 36” (larger than the one to be used for this project) has an intake velocity of approximately 95 cm/s at a distance of 1 meter from the dredge head and that the velocity reduces to approximately 40cm/s at a distance of 1.5 meters, 25cm/s at a distance of 2.0 meters and less than 10cm/s at a distance of 3.0 meters. Clarke also reports on swim tunnel performance tests conducted on juvenile and subadult Atlantic, white and lake sturgeon. He concludes that there is a risk of sturgeon entrainment only within 1 meter of a cutterhead dredge head with a 36” pipe diameter and suction of 4.6m/second. This is slightly larger than the pipe on the dredge that will be used for deepening (30”).

The risk of an individual shortnose sturgeon being entrained in a cutterhead dredge is difficult to calculate. While a large area overall will be dredged, the dredge operates in an extremely small area at any given time (i.e., the river bottom in the immediate vicinity of the intake). As shortnose and Atlantic sturgeon are well distributed throughout the action area and an individual would need to be in the immediate area where the dredge is operating to be entrained (i.e., within 1 meter of the dredge head), the overall risk of entrainment is low. It is likely that the nearly all shortnose and Atlantic sturgeon in the action area will never encounter the dredge as they would not occur within 1 meter of the dredge. Information from the tracking studies in the James and Delaware river supports these assessments of risk, as none of the tagged sturgeon were attracted to or entrained in the operating dredges.

Table 16 describes remaining deepening work to be done with a cutterhead dredge. Deepening in Reach B is planned with a cutterhead dredge.

Table 16: Scheduled dredging by reach, date and volume to be removed

Channel Reach	Volume (CY)	Scheduled Dates
B (rkm 119-137)	3,485,469	August 1, 2016 – March 15, 2017

Sea turtles are extremely unlikely to occur in Reach B and therefore, would not be exposed to effects of dredging in this reach.

The entrainment of five sturgeon in the upper Delaware River (outside of the action area) indicates that entrainment of sturgeon in cutterhead dredges is possible. However, there are several factors that may increase the risk of entrainment in that area of the river as compared to the reaches being deepened. All five entrainments occurred during the winter months in an area where shortnose sturgeon are known to concentrate in dense aggregations; sturgeon in these aggregations rest on the bottom and exhibit little movement and may be slow to respond to stimuli such as an oncoming dredge. These winter aggregations are not known to occur in the areas where deepening and maintenance of the deepened channel will occur; therefore, we expect the risk of entrainment to be lower in the action area than it is in the upper river. . During the winter months, cutterhead dredging is scheduled to occur in Reach B. Sturgeon in this reach appear to be more active than sturgeon in the overwintering aggregations near Duck and

Newbold Island (ERC 2011, ERC 2007, ERC 2014, Fisher 2011; also see discussion of behavior of sturgeon during winter months in section 7.4.3 below). As such, we expect sturgeon in Reach B to be more likely to avoid the cutterhead and for the likelihood of individuals to be within 1 meter of the draghead to be very low. The tracking of sturgeon movements during cutterhead dredging in Reach B in November and December (ERC 2012) supports this conclusion.

In total, approximately 3.5 million cy of material will be removed with a cutterhead dredge for the remaining deepening during one dredge event in Reach B. Because the only entrainment of Atlantic or shortnose sturgeon in cutterhead dredges in the United States has been the five shortnose sturgeon found at the disposal site in the upper Delaware River it is difficult to predict the number of shortnose or Atlantic sturgeon that are likely to be entrained during the deepening project. Based on the available information presented here, entrainment in a cutterhead dredge is likely to be rare, and would only occur if a sturgeon was within 1 meter of the dredge head. This determination applies to all life stages of sturgeon that are likely to be in the action area during the time of year when dredging will occur, including young of year, juveniles and subadult shortnose and Atlantic sturgeon and adult shortnose sturgeon. However, because we know that entrainment is possible, we expect that over the duration of the deepening project, some entrainment will occur. Based on the predicted rarity of the entrainment event, we expect that no more than one shortnose sturgeon and no more than one Atlantic sturgeon will be entrained during the deepening of Reach B. Therefore, we anticipate the entrainment of no more than one shortnose sturgeon and one Atlantic sturgeon in the remaining work to complete the deepening with a cutterhead dredge (one of each species) in Reach B (July 2016 – March 2017). The entrained shortnose sturgeon could be juveniles or adults. The entrained Atlantic sturgeon could be young of year, juveniles or subadults. Based on the mixed stock analysis, it is likely that the entrained Atlantic sturgeon will originate from the New York Bight DPS but could also originate from the Gulf of Maine, Chesapeake Bay or South Atlantic DPS. Given the low numbers of Carolina DPS fish in the action area and the low number of mortalities anticipated, it is unlikely that there will be any mortality of any Carolina DPS Atlantic sturgeon.

Due to the suction, travel through up to three miles of pipe and any residency period in the disposal area, entrained shortnose and Atlantic sturgeon are expected to be killed.

7.2.2 Anticipated Interactions with Sturgeon during Maintenance of the 45' Channel with a Cutterhead Dredge - Reaches AA, A, B, and C

As explained above, approximately 3,845,000 cy of material will be removed from the river (reaches AA, A, B and C) each year to maintain the channel at 45' depth. All dredging will occur between August and December. A USACE cutterhead dredge is planned for use for all maintenance dredging activities.

As explained above, we have calculated an entrainment/capture rate of one shortnose sturgeon and one Atlantic sturgeon for every cutterhead dredge event in the river. As such, no more than one shortnose sturgeon and no more than one Atlantic sturgeon are likely to be killed during each year of maintenance dredging. Maintenance dredging is expected to occur annually as deepening in each reach is completed. We expect adult Atlantic sturgeon to be too large to be vulnerable to entrainment; therefore, we expect any entrained sturgeon to be juvenile or adult shortnose

sturgeon or juvenile or subadult Atlantic sturgeon. Therefore, between now and 2027, we anticipate the entrainment of 12 shortnose sturgeon and 12 Atlantic sturgeon at an average rate of one per year. Using mixed stock analysis explained above, we have determined that Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. Given these percentages, we expect that of the 12 Atlantic sturgeon likely to be killed during maintenance dredging, seven will originate from the New York Bight DPS, three from the Chesapeake Bay DPS, one from the South Atlantic DPS and one from the Gulf of Maine DPS. Given the low numbers of Carolina DPS fish in the action area and the low number of mortalities anticipated, it is unlikely that there will be any mortality of any Carolina DPS Atlantic sturgeon.

7.2.3 Interactions with the Sediment Plume

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 with a pipeline dredge minimizes the amount of material re-suspended in the water column as the material is essentially vacuumed up and transported to the disposal site in a pipe.

As reported by USACE, a near-field water quality modeling of dredging operations in the Delaware River was conducted in 2001. The purpose of the modeling was to evaluate the potential for sediment contaminants released during the dredging process to exceed applicable water quality criteria. The model predicted suspended sediment concentrations in the water column at downstream distances from a working cutterhead dredge in fine-grained dredged material. Suspended sediment concentrations were highest at the bottom of the water column, and returned to background concentrations within 100 meters downstream of the dredge.

In 2005, FERC presented NMFS with an analysis of results from the DREDGE model used to estimate the extent of any sediment plume associated with the proposed dredging at the Crown Landing LNG berth (FERC 2005). The model results indicated that the concentration of suspended sediments resulting from hydraulic dredging would be highest close to the bottom and would decrease rapidly downstream and higher in the water column. Based on a conservative (i.e., low) TSS background concentration of 5 mg/L, modeling results of cutterhead dredging indicated that elevated TSS concentrations (i.e., above background levels) would be present throughout the bottom six feet of the water column for a distance of approximately 1,000 feet (USACE 1983). Based on these analyses, elevated suspended sediment levels are expected to be present only within 1,000 feet of the location of the cutterhead. Turbidity levels associated with cutterhead dredge sediment plumes typically range from 11.5 to 282 mg/L with the highest levels detected adjacent to the cutterhead and concentrations decreasing with greater distance from the dredge (see Nightingale and Simenstad 2001).

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 580 mg/L to 700,000 mg/L depending on species. Sublethal effects have been observed at substantially

lower turbidity levels. For example, prey consumption was significantly lower for striped bass larvae tested at concentrations of 200 and 500 mg/L compared to larvae exposed to 0 and 75 mg/L (Breitburg 1988 in Burton 1993). Studies with striped bass adults showed that pre-spawners did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Moiser 1976 and Combs 1979 in Burton 1993). While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, shortnose 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.

The life stages of sturgeon most vulnerable to increased sediment are eggs and non-mobile larvae which are subject to burial and suffocation. As noted above, no shortnose sturgeon eggs and/or larvae will be present in the action area. Juvenile and adult shortnose sturgeon are frequently found in turbid water and would be capable of avoiding any sediment plume by swimming higher in the water column. Reaches A and B overlap with the presumed Atlantic sturgeon spawning sites. Dredging (deepening for Reach B and maintenance in Reaches A and B) is scheduled to occur in these reaches between August 1 and March 15. By August 1, any Atlantic sturgeon spawned that year (April/May) would be one-two months old and would be mobile. All sturgeon in the action area at this time of year would be sufficiently mobile to avoid any sediment plume and would not be vulnerable to burial and suffocation. Therefore, any shortnose and Atlantic sturgeon in the action area during dredging would be capable of avoiding any sediment plume by swimming around it.

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. While the increase in suspended sediments may cause shortnose sturgeon to alter their normal movements, any change in behavior is likely to be insignificant as it will only involve movement further up in the water column. Based on this information, any increase in suspended sediment is not likely to affect the movement of shortnose sturgeon between foraging areas and/or concentration areas during any phase of dredging or otherwise negatively affect shortnose sturgeon in the action area.

7.3 Dredged Material Disposal

As indicated above, all material removed at Reach B and upper Reach E, and material removed from Reach D (every eight years) will be disposed of at one of the existing confined disposal facilities. When a cutterhead dredge is used, the material is piped directly from the intake to an upland disposal area. The pipe will extend up to three miles, depending on the distance between the dredge site and the disposal site. The pipe will be approximately 30" in diameter and be laid on the river bottom. While the presence of the pipe will cause a small amount of benthic habitat to be unavailable to sturgeon and sea turtles, the extremely small area affected will cause any effects to be insignificant and discountable. There are not likely to be any other effects to sturgeon or sea turtles from disposal of material at upland disposal sites.

Material removed from lower Reach E, approximately 2.1 million cy, will be disposed of at the Broadkill Beach disposal area. Additionally, material removed from Reach D (approximately 33,000 cy every 8 years), will be placed on Oakwood Beach. For these projects, sand will be

placed along the shoreline. While this could cause a small increase in suspended sediment in the immediate vicinity of sand placement, any effects are likely to be minor and temporary. Impacts associated with this action include a short term localized increase in turbidity during disposal operations. During the discharge of sediment at a disposal site, suspended sediment levels have been reported as high as 500mg/L within 250 feet of the disposal vessel and decreasing to background levels (i.e., 15-100mg/L depending on location) within 1000-6500 feet (USACE 1983). For this project, USACE has reported that because the dredged material is clean sand, the material will settle out quickly and any sediment plume will be localized and temporary. Any sea turtles or sturgeon in the vicinity of the beach disposal sites during disposal may temporarily avoid the disposal area; however, as any effects to movements will be small and temporary, these effects will be insignificant. Effects of disposal on prey resources are considered in section 7.5.

7.4 Blasting and Mechanical Dredging

As part of the proposed deepening project approximately 250,000 cubic yards of bedrock, covering a total of 18 non-contiguous acres near Marcus Hook, Pennsylvania (rkm 123-136) would be removed to deepen the navigation channel in this area. Blasting and removal of rock with a mechanical dredge will occur in areas where bedrock creates areas shallower than 45'. Blasting and rock removal will occur over two winter seasons (December 1, 2015 – March 15, 2016 and December 1, 2016 – March 15, 2017). During this time of year, the majority of adult shortnose sturgeon are expected to be located at the overwintering area between rkm 190 and 211 which is over 53 river kilometers from the blasting site (rkm 123-136). However, recent studies confirm the presence of adult and juvenile shortnose sturgeon and juvenile Atlantic sturgeon in this area during the winter months.

Studies conducted by USACE in March 2005 indicate that sturgeon are present in the Marcus Hook area during the winter months. Tracking studies reported by Brundage and O'Herron (2009) and Fisher (2011), confirm the use of Marcus Hook by juvenile shortnose and Atlantic sturgeon during the winter months. While the three sturgeon observed on video at the Marcus Hook area could not be identified to species, the size of the fish suggests that they could be adult shortnose sturgeon or subadult Atlantic sturgeon. The density estimate calculated in Versar 2006 (which was based on the video monitoring at Marcus Hook) are 0.005 sturgeon/100 m, or one sturgeon per 20,000m. The 2014 pilot relocation trawl project also documented shortnose and Atlantic sturgeon in the Marcus Hook area. Neither of the studies carried out by Brundage and O'Herron nor Fisher provide a density estimate for sturgeon in the Marcus Hook area nor an estimate of the number of sturgeon likely to be in the area in the winter months. Brundage and O'Herron (2014b) performed a study to determine sturgeon's preference of rock vs. soft bottom river bottom habitat in the blast area. The researchers deployed an array of VPS receivers to track sturgeon movement in the study area, which contained several large rock outcrops, as well as areas of soft sediment (fine-grained silts and clays). 1,322 movement detections were logged for 17 Atlantic sturgeon, and 13,151 detections were recorded for 63 shortnose sturgeon. 471 (47%) of the Atlantic sturgeon detections were in rock areas, and 532 (53%) were in non-rock areas. 3,484 (38.8%) of shortnose sturgeon detections were in rock areas, and 5,499 (61.2%) were in non-rock areas. The authors had expected sturgeon to spend the majority of their time in non-rock areas, where there is more habitat for benthic invertebrates. The substantial number of detections over rock habitat for both species showed that sturgeon may use the rock areas as

shelter from currents, while possibly feeding in pockets of soft bottom habitat between the rocks.

Blasting operations would occur up to seven days a week during the December 1 – March 15 blasting period. However, only one to two blasts will occur each day, with each blast lasting for approximately 15 seconds. On days where two blasts occur, the detonations are expected to be several hours apart. Blasting could impact sturgeon by causing physical injury or mortality to individual fish and by displacing sturgeon from the area where blasting is occurring. Effects to sturgeon also include modifications to habitat, the benthic community and reduced foraging opportunities.

The blasting plan has been designed by USACE to minimize the potential for fish mortality. As such, as noted above, all blasting will occur between December 1 and March 15 when fish density is expected to be lowest and to avoid interacting with or disturbing sturgeon spawning migrations. The following measures will be taken to reduce the potential for fish mortality:

- Perform relocation trawling before and during blasting activities;
- Monitor sturgeon movement using passive and active acoustic monitoring;
- Use acoustic deterrent system prior to detonation events;
- Minimize the size of explosive charges per delay (time lag during detonation) and the number of days of explosive exposure;
- Subdivide the explosives deployment, using suitable detonating caps with delays or delay connectors for detonation cord, to reduce the seismic energy and total pressure changes induced by the blasting;
- Use decking (explosives separated by delays) in drill holes to reduce total pressure changes;
- Use angular stemming material in the blasting holes above the explosive charges (specifically sized angular rock fragments backfilled in the drill holes to contain the explosive energy and reducing the unwanted effects of a pressure waves emanating from the blast and flyrock) ;
- Use scare charges for each blast; and,
- Monitor impacts to fish from blasting.

Relocation trawling will be initiated in mid-November 2015 and 2016 approximately two weeks prior to the anticipated start of blasting operations on December 1, 2015 and 2016. Initial trawling efforts will attempt to remove as many sturgeon as possible from the blasting area. Trawling will be performed every other day during blasting to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver. Data from passive acoustic monitoring (using 13 VEMCO VR2W receivers) will be downloaded at least every five days to track the potential movement of tagged sturgeon toward the blasting area. Active acoustic monitoring (using a VEMCO VR100 receiver and an omnidirectional hydrophone) will alert USACE to the presence of tagged sturgeon in the immediate vicinity of the blast location. USACE will also use a DIDSON multi-beam sonar “acoustic camera.” The 500 foot radius of the blast site will be monitored for sturgeon (fish do not have to be tagged to be detected) using the DIDSON starting 1-2 hours and ending 15 minutes before each detonation. Blasting will be delayed until detected sturgeon leave. The acoustic deterrent system

will be an Applied Acoustic Engineering Ltd. (AAE) “boomer” that will produce a low frequency sound of less than or equal to 204 dB re 1 μ Pa peak at a repetition of 20 booms per minute for at least 5 hours prior to each detonation.

Scare charges will be used for each blast. A scare charge is a small charge of explosives detonated immediately prior to a blast for the purpose of scaring aquatic organisms away from the location of an impending blast without producing so much pressure or noise that they could be injured or killed. Two scare charges will be used for each blast. The detonation of the first scare charge will be at 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. Fish may not locate the origin of the first scare charge. The second scare charge allows these creatures to better locate the source of the charge and maneuver away from the source. Blast pressures will be monitored and upper limits will be imposed on each blast, with average pressure not exceeding 70 pounds per square inch (psi) at a distance of 140 feet and maximum peak pressure not exceeding 120 psi at a distance of 140 feet.

7.4.1 Available Information on Effects of Blasting on Fish

There have been numerous studies that have assessed the direct impact of underwater blasting on fish. While not all of the studies have focused exclusively on shortnose sturgeon, the results demonstrate that blasting does have an adverse impact on fish. Teleki and Chamberlain (1978) found that several physical and biological variables were the principal components in determining the magnitude of the blasting effect on fish. Physical components include detonation velocity, density of material to be blasted, and charge weight, while the biological variables are fish shape, location of fish in the water column, and swimbladder development. Composition of the explosive, water depth, and bottom composition also interact to determine the characteristics of the explosion pressure wave and the extent of any resultant fish kill. Furthermore, the more rapid the detonation velocity, the more abrupt the resultant hydraulic pressure gradient, and the more difficulty fish appear to have adjusting to the pressure changes.

A blasting study conducted in Nanticoke, Lake Erie, found that fish were killed in radii ranging from 20 to 50 m for 22.7 kg per charge and from 45 to 110 m for 272.4 kg per charge (Teleki and Chamberlain 1978). Approximately 201 blasts were detonated in 4 to 8 m of water. Of the thirteen fish species studied, mortality differed by species at identical pressure. No shortnose sturgeon were tested. Common blast induced injuries included swimbladder rupturing and hemorrhaging in the coelomic and pericardial cavities.

The effects of blasting on thirteen species of fish were measured in deep water (46 m) explosion tests in the Chesapeake Bay opposite the mouth of the Patuxent River (Wiley *et al.* 1981). No shortnose sturgeon were tested. Fish were held in cages at varying depths during 16 midwater detonations with 32 kg explosives. For the 32 kg charges, the pressure wave was propagated horizontally most strongly at the depth at which the explosion occurred. While the extent of the injury varied with species, the fish with swimbladders are far more vulnerable than those lacking swimbladders, and toadfish and catfish were the most resistant to damage of those species with a swimbladder.

Many fish exposed to blasting exhibit injuries to the kidney and swimbladder, thus affecting their

fitness (Wiley *et al.* 1981). Efficient osmoregulation is very important in fishes; even slight bruises to the kidney could seriously affect this efficiency, causing at least a higher expenditure of energy. Burst swimbladders cause the fish to lose their ability to regulate the volume of their swimbladders (destroying buoyancy control) and probably increases their vulnerability to predators.

Wiley *et al.* (1981) found that the oscillatory response of the swimbladder was a likely cause of the fishes' injuries. Their analyses demonstrate that fish mortality is strongly dependent on the depth of the fish. For larger fish (like shortnose sturgeon) at shallower depths (~7 to 11 m), the swimbladder does not have time to fully respond to the positive portion of the explosion wave. Thus, at shallow depth the larger fish are in effect protected from harm by their swimbladders, while at the resonance depth their swimbladders are burst.

Burton (1994) conducted experiments to estimate the effects of blasting to remove approximately 1,600 cubic yards of bedrock during construction of a natural gas pipeline in the Delaware River near Easton, Pennsylvania (upriver from Marcus Hook area). American shad and smallmouth bass juveniles were exposed to charges of 112.5 and 957 kg of explosives in depths ranging between 0.5 and 2 m. The fish were caged at a range of distances from the blasts. Tests with American shad were inconclusive due to an unavoidable delay between stocking the chambers and detonation of the explosives; however, successful tests with smallmouth bass suggested that the explosives created a maximum kill radius of 12 m (for both charge magnitudes). No fish were killed by the shock wave at the 24 m position and beyond.

The preceding studies were conducted on other fish species, but the nature of the injuries and the optimal distance from the detonations could be applied to blasting activities and shortnose sturgeon. The effects of blasting on shortnose sturgeon have been examined however. Test blasting was conducted in the Wilmington Harbor, North Carolina, in December 1998 and January 1999 in order to adequately assess the impacts of blasting on shortnose sturgeon, the size of the LD1 area (the lethal distance from the blast where 1% of the fish died), and the efficiency of an air curtain for mitigating blast effects. An air curtain is a stream of air bubbles created by a manifold system on the river bottom surrounding the blast. In theory, when the blast occurs the air bubbles are compressed, and the blast pressure is reduced outside the air curtain.

As explained in Moser 1999(a), the test blasting consisted of 32-33 blasts (3 rows of 10 to 11 blast holes per row with each hole and row 10 feet apart), about 24 to 28 kg of explosives per hole, stemming each hole with angular rock, and an approximate 25 m/sec delay after each blast. During test blasting, 50 hatchery reared juvenile striped bass and shortnose sturgeon were placed in 0.25" plastic mesh cylinder cages (2 feet in diameter by 3 feet long) 3 feet from the bottom (worst case scenario for blast pressure as confirmed by test blast pressure results) at 35, 70, 140, 280, and 560 feet upstream and downstream of the blast location. For each test, 200 caged shortnose sturgeon were held at a control location 0.5 mi from the test blast area. The caged fish had a mean weight of 55 grams. The cages were enclosed in a 0.6" nylon mesh sock to prevent the escape of any sturgeon if the cage was damaged during blasting. The caging experiments were conducted during a total of seven blasts between December 9, 1998 and January 7, 1999. Three test blasts were conducted with the air curtain in place, and four were conducted without

the air curtain. The air curtain (when tested) was 50 feet from the blast. The caged fish were visually inspected for survival just after the blast and after a 24-hour holding period. Mortality rates for control fish were generally low, with 15 fish dead or mortally injured on inspection (out of a total of 1,400 samples). The numbers of injured, dead, and mortally injured sturgeon varied greatly between tests. Of the 500 fish tested during each blast, mortalities (dead or mortally injured) ranged from one to 89 fish. Mortality rates for shortnose sturgeon as compared to the other species tested were low, with the author of the report concluding that this was likely due to the larger size of shortnose sturgeon tested (approximately 30cm average) as compared to the size of the other species (3cm – 20cm).

In addition to the external examinations of fish immediately following the blast and 24 hours later, a sample of 10 randomly selected, apparently unaffected, sturgeon from each of seven cages nearest the blasts were sacrificed and later necropsied (Moser 1999b). After the necropsy was completed, the total extent of injury was scored on a scale of 0-10, with 10 being the most severe level of injury observed. It is important to note that all of the fish necropsied were alive 24 hours following the blast and appeared to be uninjured based on the initial external observations. Fish scored at 7 or higher were thought to be unlikely to survive and function normally with the injuries they sustained. Injuries ranged from no sign of external injury to extensive internal hemorrhaging and ruptured swim bladders.

All fish necropsied were in apparently normal condition when sacrificed 24 hours after the blast. The fish were swimming normally in their cages and exhibited no outward signs of stress or physical discomfort (Moser 1999b). However, internal examinations revealed extensive damage in many of the fish necropsied. Of the 70 sturgeon necropsied, ten had an index of injury of 7 or higher, meaning that they likely would not have survived the injuries sustained during blasting. While sturgeon had relatively little damage to their swim bladders, they more often had distended intestines with gas bubbles inside and hemorrhage to the body wall lining. In the fish caged 70 feet away, there was no sign of hemorrhage or swim bladder damage but two of the fish exhibited distended intestines, which may have been caused by the blast. Moser (1999) speculated that sturgeon fared better than striped bass because their air bladder has a free connection to the esophagus, allowing gas to be expelled rapidly without damage to the swim bladder. Additionally, there was no clear relationship between size and the Index of Injury, size and gut fullness, or Index of Injury and gut fullness. The author notes that external observation of the fish following blasting was not sufficient to identify all blast-related injuries and that many of the internal injuries observed in fish that externally appeared unaffected would have resulted in eventual mortality.

7.4.2 Effects of Proposed Blasting on Shortnose and Atlantic Sturgeon

During the winter months, we expect most pre-spawning adult shortnose sturgeon to overwinter near Duck and Newbold Island, well upstream of the blasting area (see O'Herron *et al.* 1996). Adult and subadult Atlantic sturgeon leave the river by November and do not return until the spring; therefore, adult and subadult Atlantic sturgeon are unlikely to be present in Marcus Hook in the winter months. Several recent studies have confirmed the use of the Marcus Hook area by juvenile and adult shortnose and juvenile Atlantic sturgeon in the winter months (see ERC 2006, Fisher 2011, Brundage and O'Herron 2009, 2014). Tracking studies confirm the presence of

shortnose and Atlantic sturgeon in the Marcus Hook area in the time of year that blasting will occur.

Sturgeon appear to be able to withstand some degree of blasting at a certain distance from the detonation, but it is apparent from the study results outlined above that blasting may injure the species both internally and externally. Any sturgeon within 500 feet of the blasts could experience injury or mortality. As noted above, the severity of the impact that blasting has on fish is dependent on several biological and physical variables. Results from previous blasting studies conducted on thirteen species of fish other than shortnose sturgeon, revealed that swimbladder rupture and hemorrhaging in the pericardial and coelomic cavities were common injuries that resulted. While studies on shortnose sturgeon revealed that they also suffer from swimbladder ruptures, more common blast induced injuries that resulted were distended intestines with gas bubbles inside and hemorrhage to the body wall lining (Moser 1999a, Moser 1999b). Overall, however, it is difficult to determine the extent of internal injury because many fish did not exhibit external stress or physical discomfort despite extensive internal damage. Approximately 10% of fish that appeared to have suffered no injury, sustained injuries from the blasting that it is speculated would have led to their eventual death. If shortnose sturgeon are present in the action area during blasting, they may suffer injury and/or mortality.

Based on the information presented above, shortnose and Atlantic sturgeon within 500 feet of a detonation resulting in peak pressures of 120 psi and average pressure of 70 psi, consistent with the proposed action would be exposed to noise and pressure levels that could cause adverse effects. These effects could range from avoidance behaviors, temporary stunning, external or internal injury with full recovery, injury with delayed mortality or injury sufficient to cause immediate mortality. Based on the best available information, it is likely that the smaller the fish is and the closer it is to the blast the more significant the injuries would be.

7.4.3 Relocation Trawling

As explained above, the relocation trawling will occur in the area where blasting is planned. For two weeks prior to the commencement of the two blasting seasons (we expect trawling to begin November 16, 2015 and November 14, 2016, respectively), USACE will trawl intensively in the Marcus Hook blasting area in an attempt to remove as many Atlantic and shortnose sturgeon as possible from the 500 foot radius of any detonation. It will not be possible to trawl within the immediate vicinity of a blasting site once the charges are being set. Once blasting begins, trawling will be performed every other day (weather permitting) to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver. Trawling procedures were designed to be consistent with our recommendations for sturgeon research (see Damon-Randall *et al.* 2010 and Kahn and Mohead 2010).

Capturing

Capture in trawl gear can result in injury and mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Moser and Ross 1995, Collins *et al.* 2000, Moser *et al.* 2000). Trawling to capture sturgeon is made more safe and reliable by limiting the duration of the trawls. Most negative effects resulting from trawling capture of sturgeon typically are related to the speed and duration of the trawl (Moser *et al.* 2000).

Atlantic sturgeon captured in trawl gear as bycatch of commercial fishing operations have a mortality rate of approximately 5% (based on information in the NEFOP database). Short tow duration and careful handling of any sturgeon once on deck is likely to result in a very low potential for mortality. We reviewed records from eight long-term trawl surveys carried out by Northeast States (ME/NH, MA, CT, NJ, DE, VA) that capture sturgeon, including two surveys that occur in the Delaware River. These surveys have collectively operated for thousands of hours with some dating back as far as the 1960s. A total of nearly 900 Atlantic and shortnose sturgeon have been captured during these surveys, with no recorded injuries or mortalities. All of these surveys operate with tow times of thirty minutes or less. Similarly, the NEFSC surveys have recorded the capture of 110 Atlantic sturgeon since 1972. The NEAMAP survey has captured 102 Atlantic sturgeon since 2007. To date, there have been no recorded injuries or mortalities. In the Hudson River, a trawl survey that incidentally captures shortnose and Atlantic sturgeon has been ongoing since the late 1970s. To date, no injuries or mortalities of any sturgeon have been recorded. During the Brundage and O’Herron (2014a) trawling relocation study, two small sturgeon (one Atlantic 28.2 cm TL; one shortnose 30.6 cm TL) were injured during trawling. The Atlantic suffered a broken primary ray on its right pectoral fin and injury to its pectoral girdle, while the shortnose also had an injury to its pectoral girdle. Both injuries were likely caused by debris in the trawl net. Both were released but had difficulty maintaining equilibrium and may not have survived. Therefore, two of the 104 sturgeon captured in this study were injured (1.9%). Relocation trawling for this project will use a net that has been modified based on the performance of nets in the Brundage and O’Herron (2014a) study. During testing, the modified net successfully trawled through a number of rock areas with no hangs or serious damage to the net. With the new net, we expect less debris to be picked up in the trawl with sturgeon. Based on this information, we expect it to be unlikely that significant injury or mortality of any shortnose or Atlantic sturgeon will occur, but we cannot rule it out given that debris and rock that exist in the area where trawling will occur and may cause injury. Given the changes in the net, we expect fewer sturgeon to be injured during relocation trawling than were injured during the pilot study. As such, we expect no more than 1% of sturgeon will be injured. Based on the lack of mortalities in the other short tow-time trawls mentioned above, we do not expect any sturgeon to be killed during relocation trawling.

Handling

It is expected that up to 816 shortnose and Atlantic sturgeon will be captured and handled per blasting season (1,632 total between December 2015 and March 2017).¹⁹ Based on the ratio of shortnose and Atlantic sturgeon captured during the pilot study (36 Atlantics, 67 shortnose), we expect 35% of the captured sturgeon to be Atlantics and 65% to be shortnose. As such, we expect the capture and relocation of up to 1,061 shortnose sturgeon and 571 Atlantic sturgeon

¹⁹ In Brundage and O’Herron (2014a), 9 days of trawling (total of 460 min, or almost an hour per day) in the blast area resulted in the capture of 104 sturgeon (approximately 12 sturgeon per day). We assume the same level of trawling effort per day will be applied to this project. Relocation trawling will occur every day from November 16 – November 30, and then every other day from December 1 – March 15 (total of 68 days, weather permitting). So at the rate of 12 sturgeon per day, we estimate that 816 sturgeon per blasting season (1,632 total between December 2015 and March 2017) will be captured and relocated.

over the two seasons of blasting. Handling and restraining sturgeon may cause short term stress responses, but individuals are expected to quickly recover from this stress due to the short duration of handling. Under some conditions, pre-spawning adults will interrupt or abandon their spawning migrations after being handled (Moser and Ross 1995); however, this project will not capture sturgeon during their migration to the spawning grounds, so this is unlikely to occur.

To minimize capture and handling stress, researchers will hold sturgeon in net pens or in holding tanks (as available), provide fish with a continuous flow of water, and minimize the amount of time the fish are handled and held. For most planned procedures, the total time required to complete routine handling and tagging would be no more than 15 minutes. Moreover, following processing, sturgeon would be returned to the net pen or holding tank for observation, ensuring full recovery prior to release. Sturgeon would be checked for buoyancy problems and treated with a slimecoat restorant prior to release, as well as monitored for proper swimming behavior after release. Total holding time would never be longer than three hours, including transport time to the upstream release location, from capture until release.

The handling, holding, weighing, measuring, and photographing procedures will follow our protocols (Kahn and Mohead 2010). We expect that individual fish would normally experience no more than short-term stresses as a result of these activities. Researchers have taken measurements and weights of thousands of sampled animals in the proposed manner with no apparent ill effect. No injury would be expected from these activities, and individuals would be worked up as quickly as possible to minimize stress. The researchers will also follow procedures designed to minimize the risk of either introducing a new pathogen into a population or amplifying the rate of transmission from fish to fish of an endemic pathogen during handling. The proposed methods of handling fish will minimize effects resulting from routine handling and holding.

Tissue sampling

Genetic samples will be taken from all captured fish. This will be done by taking a small (1 cm²) tissue sample, clipped with surgical scissors from a section of soft fin rays. This procedure does not appear to impair the sturgeon's ability to swim and is not thought to have any long-term adverse impact (Kahn and Mohead 2010). Many researchers, including the those who will execute the relocation trawling, have removed tissue samples according to this same protocol reporting no adverse effects (Wydoski and Emery 1983); therefore, we do not anticipate any long-term adverse effects to the sturgeon from this activity.

Passive Integrated Transponder (PIT) Tags

All shortnose and Atlantic sturgeon captured that are previously unmarked will be marked with PIT tags. No fish would be double-tagged with PIT tags. Prior to PIT tagging, the entire dorsal surface of each fish would be scanned to detect previous PIT tags.

PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996, Skalski *et al.* 1998, Dare 2003), amphibians (Thompson 2004), reptiles (Cheatwood *et al.* 2003, Germano and Williams 2005), birds (Boisvert and Sherry 2000, Green *et al.* 2004), and

mammals (Wright *et al.* 1998, Hilpert and Jones 2005). Problems from PIT tags result from the insertion of tags too big for the size of the animal or from pathogen infection (Muir *et al.* 2001; Henne *et al.*, unpublished). When tag size is appropriate for the animal, no adverse effect on the growth, survival, reproductive success, or behavior of individual animals are anticipated (Brännäs *et al.* 1994, Elbin and Burger 1994, Keck 1994, Jemison *et al.* 1995, Clugston 1996, Skalski *et al.* 1998, Hockersmith *et al.* 2003). PIT tags are biologically inert and have not been shown to cause scarring or tissue damage or otherwise adversely affect growth or survival (Brännäs *et al.* 1994). As the recommended procedures contain limits on the size of the tags based on the size of the fish, and proper sterilization protocols, we do not anticipate problems related to tag size or introduction of pathogens. Therefore, we do not anticipate any injury or mortality to result from insertion of PIT tags.

Floy Tags

Captured sturgeon would also be marked with Floy tags. These are external tags that are readily visually observed. This tagging methodology is useful when trying to determine if any sturgeon captured in the trawls have returned to the area from the relocation sites. Floy tags would be anchored in the dorsal fin musculature base and inserted forwardly and slightly downward from the left side to the right through dorsal pterygiophores. After removing the injecting needle, the tag would be spun between the fingers and gently tugged to be certain it is locked in place.

Smith *et al.* (1990) compared the effectiveness of dart tags with nylon T-bars, anchor tags, and Carlin tags in shortnose and Atlantic sturgeon. Carlin tags applied at the dorsal fin and anchor tags in the abdomen showed the best retention. It was noted however, that anchor tags resulted in lesions and eventual breakdown of the body wall if fish entered brackish water prior to their wounds healing. Collins *et al.* (1994) found no significant difference in healing rates (with T-bar tags) between fish tagged in freshwater or brackish water. Clugston (1996) also looked at T-bar anchor tags placed at the base of the pectoral fins and found that beyond two years, retention rates were about 60%. Collins *et al.* (1994) compared T-bar tags inserted near the dorsal fin, T-anchor tags implanted abdominally, dart tags attached near the dorsal fin, and disk anchor tags implanted abdominally. They found that for the long-term, T-bar anchor tags were most effective (92%), but also noted that all of the insertion points healed slowly or not at all, and, in many cases, minor lesions developed.

The attachment of tags may cause some discomfort and pain to sturgeon. The injection of Floy tags may result in more noticeable reactions than the injection of PIT tags. Injury may result during attachment, although the potential for this is seriously reduced when tags are applied by experienced biologists and technicians as they will be in this case.

Injection of Floy tags into the dorsal musculature may result in raw sores that may enlarge over time with tag movement (Collins *et al.* 1994; Guy *et al.* 1996). Beyond the insertion site, it is unknown what effects on the fish the attachment of Floy tags may have. We know of no long-term studies evaluating the effect of these tags on the growth or mortality of tagged shortnose sturgeon. Anecdotal evidence recounted in NOAA's protocol (Moser *et al.* 2000) suggests that Floy tags have little impact on the fish because a number of shortnose were recovered about 10-years after tagging although no data are available to evaluate any effects on growth rate.

Studies on other species suggest that the long-term effect of injecting anchor tags into the muscle may be variable. Researchers have observed reduced growth rates in lemon sharks and northern pike from tagging, whereas studies of largemouth bass did not depict changes in growth rates (Tranquilli and Childers 1982; Manire and Gruber 1991; Scheirer and Coble 1991).

Sterile tagging techniques will be used in order to minimize the above- described potential negative impacts. Based on this, we anticipate that minor, short term injuries, such as lesions at the attachment point, may result from the use of Floy tags. However, we expect these to heal over time. Due to the minor nature of the injury, we do not expect the injury to result in any reductions in fitness for any individual.

Internal Sonic Transmitters

Up to 100 individual sturgeon (combination of shortnose and Atlantic) per blasting season (200 total) will be tagged with Vemco sonic transmitter devices (model V7, V9, V13 or V16). Based on the ratio of sturgeon captured during the pilot study, we expect that this will consist of 70 Atlantic sturgeon and 130 shortnose sturgeon. The weight of tags will be limited to no more than 2% of a given fish's body weight. Sonic transmitters will be attached via incision, implantation, and suturing. Active and passive tracking would follow transmitter attachment.

In general, adverse effects of these proposed tagging procedures could include pain, handling discomfort, hemorrhage at the site of incision, risk of infection from surgery, affected swimming ability, and/or abandonment of spawning runs. Choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al.* 2002).

Survival rates after implanting transmitters in shortnose sturgeon are high. Collins *et al.* (2002) evaluated four methods of radio transmitter attachment on shortnose sturgeon. They found 100% survival and retention over their study period for ventral implantation of a transmitter with internally-coiled antenna. Their necropsies indicated there were no effects on internal organs.

Dr. Collins in South Carolina (M. Collins, *pers. comm.*, November 2006) has also more recently reported no mortality due to surgical implantation of internal transmitters. Devries (2006) reported movements of 8 male and 4 female (≥ 768 mm TL) shortnose sturgeon internally radio tagged between November 14, 2004 and January 14, 2005 in the Altamaha River. Eleven of these fish were relocated a total 115 times. Nine of these fish were tracked until the end of 2005. The remaining individuals were censored after movement was not detected, or they were not relocated, after a period of 4 months. Periodic checks for an additional 2 months also showed no movement. Although there were no known mortalities directly attributable to the implantation procedure; the status of the three unlocated individuals was unknown (Devries 2006).

Growth rates after transmitter implantation are reported to decrease for steelhead trout. Welch *et al.* (2007) report results from a study to examine the retention of surgically-implanted dummy acoustic tags over a 7 month period in steelhead trout pre-smolts and the effects of implantation

on growth and survival. Although there was some influence in growth to week 12, survival was high for animals > 13 cm FL. In the following 16 week period, growth of surgically implanted pre-smolts was the same as the control population and there was little tag loss from mortality or shedding. By 14 cm FL, combined rates of tag loss (mortality plus shedding) for surgically implanted tags dropped to < 15% and growth following surgery was close to that of the controls.

Tag weight relative to fish body weight is an important factor in determining the effects of a tag (Jepsen *et al.* 2002). The two factors directly affecting a tagged fish are tag weight in water (excess mass) and tag volume. Perry *et al.* (2001) studied buoyancy compensation of Chinook salmon smolts tagged with surgical implanted dummy tags. The results from their study showed that even fish with a tag representing 10% of the body weight were able to compensate for the transmitter by filling their air bladders, but the following increase in air bladder volume affected the ability of the fish to adjust buoyancy to changes in pressure. Winter (1996) recommended that the tag/body weight ratio in air should not exceed 2%. Tags of greater sized implants produced more mortality of juvenile Atlantic salmon. There was 60% mortality (3 of 5 fish) with a 32-mm implant and 20% mortality (1 of 5 fish) with a 28-mm implant and 20% mortality (1 of 5 fish) with a 24-mm implant (Lacroix *et al.* 2004). Fish with medium and large external transmitters exhibited lower growth than fish with small transmitters or the control group (Sutton and Benson 2003).

Implanted transmitters could affect fish swimming performance. Thorstad *et al.* (2000) studied the effects of telemetry transmitters on swimming performance of adult farmed Atlantic salmon. These researchers found that swimming performance and blood physiology of adult Atlantic salmon (1021-2338 g, total body length 45-59 cm) were not affected when equipped with external or implanted telemetry transmitters compared with untagged controls. There was no difference in endurance among untagged salmon, salmon with small external transmitters, large external transmitters and small body-implanted transmitters at any swimming speed. Authors cautioned that results of wild versus farmed salmon may be different (Peake *et al.* 2007). However, a similar study using sea-ranched Atlantic salmon found no difference in endurance, similar to the farmed salmon study (Thorstad *et al.* 2000). Adams *et al.* (1993) demonstrated that juvenile Chinook salmon < 120 mm FL with either gastrically or surgically implanted transmitters had significantly lower critical swimming speeds when compared to control fish 1 day after tagging as well as at 19-23 days after tagging; however, in this study tags were more than 4.6% of the fish's body weight and the authors concluded that limiting tag size would minimize the potential for impacts to swimming performance

Since implantation requires surgery, we have considered the ability of wounds to heal successfully. Several factors can impede wound healing in fish including secondary infection and inflammation. Fish epidermal cells at all levels are capable of mitotic division, and during wound healing there is a loss of the intracellular attachments and cells migrate rapidly to cover the defect and provide some waterproof integrity (Wildgoose 2000). This leads to a reduction in the thickness of the surrounding epidermis and produces a thin layer of epidermis at least one cell thick over the wound; however the process can be inhibited by infection (Wildgoose 2000). Thorstad *et al.* (2000) reports that when examined between 6

and 20 days after tagging, incisions were not fully-healed in 13 of the 126 Atlantic salmon examined. However, the authors speculate that slow healing could be due to the storage of a large number of tagged fish in the same tanks and repeated netting and handling of the fish after tagging. Juvenile largemouth bass implanted with microradio transmitters exhibited short-term (5 days) inflammation around the incision and suture insertion points for both non-absorbable braided silk and non-absorbable polypropylene monofilament, but in the longer term (20 days) almost all sutures were shed and the incisions were completely healed (Cooke *et al.* 2003). Chapman and Park (2005) examined suture healing following a gonad biopsy of Gulf of Mexico sturgeon and found both the absorbable and nonabsorbable sutures to effectively sew the skin after biopsy with all sturgeons surviving surgery and incisions healing 30 days after the intervention.

The expulsion or rejection of surgically implanted transmitters has been reported from a number of studies. Examination of post-tagged fish in the lab and in the wild, suggests that expulsion does not cause further complications or death in fish that manifest this occurrence. Rates of tag shedding and ways of implant exits depend on species, fish condition, tag weight and environmental conditions (Jepsen *et al.* 2002). There are basically three ways of implant exit; through the incision, through an intact part of the body wall and through the intestine. Trans-intestinal expulsion is rare but a laboratory study of rainbow trout implanted with dummy tags indicated that some tags were expelled in this manner (Chisholm and Hubert 1985). Other studies have documented expulsion of tags through the body wall adjacent to the healed incision (Moore *et al.* 1990; Lucas 1989). The path of tag expulsion was able to be documented in these studies because the fish were held in a laboratory. None of these studies documented any mortality or infection as a result of tag expulsion, and fish continued to mature and behave like the control (untagged) fish. Expulsion of tags in sturgeon has also been documented (Moser and Ross 1995; Kieffer and Kynard 1993); however, because the tagged fish were recaptured in the wild, the path of tag expulsion could not be determined. However, the researchers did not document any impacts to these fish resulting from tag loss.

Coating the transmitters has been suggested to vary the rate of expulsion. It has been hypothesized that paraffin coating of the transmitter increases expulsion rate (Chisholm and Hubert 1985). Moser and Ross (1995) reported that retention of surgically implanted tags could be improved for Atlantic sturgeon when the transmitters were coated with a biologically inert polymer, Dupont Sylastic. Additionally, Kieffer and Kynard (*In press*) report that tag rejection internally is reduced by coating tags with an inert elastomer and by anchoring tags to the bodywall with internal sutures. Kieffer and Kynard's fish retained tags for their operational life, and in most cases, lasted much longer (mean, 1,370.7 days).

We expect that shortnose and Atlantic sturgeon exposed to internal sonic transmitter implantation would respond in a manner similar to the available information presented above. Survival rates are expected to be high with no ill effects on internal organs expected as a result of the transmitters. We do not expect mortality to occur as a result of this procedure, although a few tagged fish from studies reported above have disappeared and their fate was unknown. We expect that growth rates or swimming performance could be affected and that expulsion of the transmitter could occur, although, there have been no mortalities or infections reported to be

associated with expulsion. We expect that the surgical wound would heal normally, but acknowledge that adverse effects of these proposed tagging procedures could include pain, handling discomfort, hemorrhage at the site of incision, risk of infection from surgery, affected swimming ability, and/or abandonment of spawning runs. The research methodologies will minimize these risks, as choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al.* 2002).

By using proper anesthesia, sterilized conditions, and the surgical techniques described above, these procedures would not be expected to have a significant impact on the normal behavior of any tagged sturgeon. We expect all injuries to be minor and recovery to occur rapidly with no impact on fitness.

Anesthetic

Prior to surgery, sturgeon will be anesthetized with buffered tricaine methane sulfonate (MS-222). Concentrations of MS-222 of 50 mg/L will be used to sedate sturgeon from induction to a maintenance state of surgical anesthesia for implantation surgery (total loss of equilibrium, no reaction to touch stimuli, cessation of movement, except for opercula movement).

Because MS-222 is acidic and poorly absorbed, resulting in a prolonged induction time, Sodium bicarbonate (NaHCO₃) would be used to buffer the water to a neutral pH.

MS-222 is a recommended anesthetic for sturgeon research when used at correct concentrations (Moser *et al.* 2000, USFWS 2008). It is rapidly absorbed through the gills and its mode of action is to prevent the generation and conduction of nerve impulses with direct actions on the central nervous system and cardiovascular system. Lower doses tranquilize and sedate fish while higher doses fully anesthetize them (Taylor and Roberts 1999). In 2002, MS-222 was FDA-approved for use in aquaculture as a sedative and anesthetic in food fish (FDA 2002).

Increased concentrations for rapid induction are recommended for sturgeon followed by a lower maintenance dose concentration (Matsche 2011). MS-222 is excreted in fish urine within 24 hours and tissue levels decline to near zero in the same amount of time (Coyle *et al.* 2004). At the proposed rates of anesthesia, narcosis would take one minute and complete recovery time would range from three to five minutes (Brown 1988).

If administered at too high of a concentration, MS-222 can result in death or injury. A study on steelhead and white sturgeon revealed deleterious effects to gametes at concentrations of 2,250 to 22,500 mg/L MS-222, while no such effects occurred at 250 mg/L and below (Holcomb *et al.* 2004). Another study found MS-222 administered in concentrations of 125 mg/l resulted in changes to blood constituents and histological changes to the liver and gills. However, fish were expected to be able to recover from these effects and no permanent impacts were observed (Gomulka *et al.* 2008). Studies conducted by Haley 1998, Moser *et al.* 2000, Collins *et al.* 2006, 2008 show MS-222 to be a successful anesthesia with no permanent impacts to shortnose and Atlantic sturgeon when used at concentrations up to 150 mg/L.

Several studies have documented that the administration of MS-222 results in a physiological

stress response in fish but that when comparing handling stress among anesthetized fish and un-anesthetized fish, the stress response is significantly lower in the anesthetized fish (see Wagner *et al.* 2003; Holloway *et al.* 2004). Pirhonen and Schreck 2003, compared the amount of food consumed by steelhead trout anesthetized with 80 mg/l MS-222 to un-anesthetized fish. They found that while all individuals readily fed at all tested intervals (4, 24, and 48 hours after anesthesia), anesthetized fish consumed 15-20% less food than the control group. Studies indicate that anesthetized fish have elevated plasma cortisol levels following anesthesia which indicates a physiological stress response; however, the plasma cortisol levels were lower in anaesthetized fish compared to un-anesthetized fish (Wagner *et al.* 2003, Holloway *et al.* 2004).

Based on the information presented above, the use of MS-222 at the recommended dose (50mg/l) and limited to the amount of time necessary to carry out the surgical procedures will not result in any permanent physiological impacts to sturgeon and will not result in mortality. Short-term physiological stress responses, which would be measurable in blood components and cortisol levels, are likely. However, we expect all sturgeon to recover from this stress. Reduced feeding has been documented following anesthesia; however, given the small reduction in anticipated feeding and the short duration of any effects, we do not expect this to result in any long term impact to any individuals. Further, the impacts to sturgeon from the proposed handling and tag implantation will be significantly less if proper anesthesia is used.

Hydroacoustic Equipment

Passive acoustic monitoring will be conducted with 13 Vemco VR2w single-channel receivers and active acoustic monitoring will use a Vemco VR100 receiver with an omnidirectional hydrophone. DIDSON sonar gear will be used for nearfield location of sturgeon in the blast area. The use of hydroacoustic assessment is a non-invasive method. Researchers use it to collect information without physically capturing fish. Hydroacoustic equipment used in connection with this action will not be within a hearing range of Atlantic or shortnose sturgeon; therefore, there is no impact to sturgeon from using this equipment.²⁰

Effects of Relocation

Because of the time of year, any sturgeon captured in the Marcus Hook area will be overwintering there. Here, we consider the effects of removing sturgeon from one overwintering location and placing them in another overwintering location.

The available information indicates that sturgeon collected in the Marcus Hook area are likely to be juvenile shortnose or Atlantic sturgeon. Most adult shortnose sturgeon, including those that will spawn in the spring, overwinter in dense aggregations near Duck and Newbold Island (rkm 190-210). Tracking of individuals in these areas indicate that they make only localized movements and remain within a 0.5-10 km area (O'Herron *et al.* 1993). Juvenile and smaller population of adult shortnose sturgeon overwinter in lower reaches of the river and may be

²⁰ The best available information indicates that Atlantic and shortnose sturgeon are not capable of hearing noise in frequencies above 1,000 Hz (1 kHz) (Popper 2005). The DIDSON can be operated at either of two frequencies, 1.8 MHz (high frequency) or 1.1 MHz (low frequency), both of which are outside of the sturgeon hearing range.

present in the Marcus Hook area (Brundage and O'Herron 2009; Brundage and O'Herron 2014a). During the winter months, subadult and adult Atlantic sturgeon are located outside of the Delaware River (Fisher 2011). Juvenile and YOY Atlantic sturgeon are present in the Marcus Hook area in the winter (Fisher 2011; Brundage and O'Herron 2014a).

Studies tracking the movements of juvenile sturgeon in the Delaware River indicate that individual behavior is diverse, with some individuals establishing a relatively small "home range" (see Fisher 2011) during the winter months and others exhibiting extensive movements. No information on what factors contribute to different behaviors is available; these differences are seen in the same year and in fish of the same year class making it difficult to determine if there are environmental or developmental factors at play or if it is merely natural variability.

ERC (2007) tracked four shortnose sturgeon and one Atlantic sturgeon; three of the shortnose sturgeon were tracked through the winter (one shortnose was only tracked from May – August 2006). Shortnose sturgeon 171 was located in the Baker Range in early January (rkm 83), and moved upriver to the Deepwater Point Range (rkm 105) in mid-January where it remained until it moved rapidly to Marcus Hook (rkm 130) on March 12. Shortnose sturgeon 2950 was tracked through February 2, 2007. In December the fish was located in the Bellevue Range (rkm 120). Between January 29 and February 2, the fish moved between Marcus Hook (rkm 125) and Cherry Island (rkm 116). Shortnose sturgeon 2953 also exhibited significant movement during the winter months, moving between rkm 123 and 163 from mid-December through mid-March.

Fisher (2011) tagged and tracked juvenile, subadult and adult Atlantic sturgeon in the Delaware River in 2007, 2008 and 2009. All subadult and adult Atlantic sturgeon left the River by November and were not present in the river during the winter months. Young of the year sturgeon demonstrated highly variable behavior. From the mid-November to early March period, individuals either stayed within a small home range (less than 1 km) near the Marcus Hook anchorage (rkm 130) or made extensive movements (distances up to 50 km) between Philadelphia (rkm 154) and Roebling (rkm 199).

Brundage and O'Herron (2014a) assessed the feasibility study of trawling for sturgeon in and around the proposed blast area and subsequently relocating sturgeon from one overwintering site to three others further upstream (Ft. Mifflin, PA, Torresdale, PA, or Burlington, NJ)(see Figure 3). A total of 104 sturgeon were caught during trawling (includes one recapture), and 88 of those sturgeon were acoustically tagged and transported upriver. Of the 26 acoustically-tagged Atlantic sturgeon, eight were released at Ft. Mifflin, six were released at Torresdale, and 12 were released at Burlington. All of the Atlantic sturgeon released at Ft. Mifflin returned to the blasting area, taking from 0.7-14.5 days to return (mean = 4.3 days). Two of the six (33.3%) Atlantic sturgeon released at Torresdale returned to the blasting area, taking from 8.6-33.0 days to do so (mean = 20.8 days). Of the 12 Atlantic sturgeon released at Burlington, seven (58.3%) returned to the blasting area, taking from 6.4-48.4 days (mean = 18.6 days). Of the 62 acoustically-tagged shortnose sturgeon, 22 were released at Ft. Mifflin, 21 were released at Torresdale, and 19 were released at Burlington. Twenty-one of the 22 (95.5%) shortnose sturgeon released at Ft. Mifflin returned to the blasting area, taking from 0.4-54.2 days to return (mean = 15.8 days). Sixteen of the 21 (76.2%) shortnose sturgeon released at Torresdale returned to the blasting area, taking

from 1.4-56.1 days to return (mean = 22.9 days). Of the 19 shortnose sturgeon released at Burlington, 12 (63.2%) returned to the blasting area, taking from 3.2-50.7 days (mean = 18.3 days). Thirteen of the shortnose sturgeon (three released at Ft. Mifflin, five released at Torresdale, and five released at Burlington) were detected on the spawning grounds in the lower non-tidal river (rkm 221) during early to mid-April. Participation in spawning is further evidence that trawling-tagging-transportation did not inhibit sturgeon from participating in natural migrations and behaviors post-study.

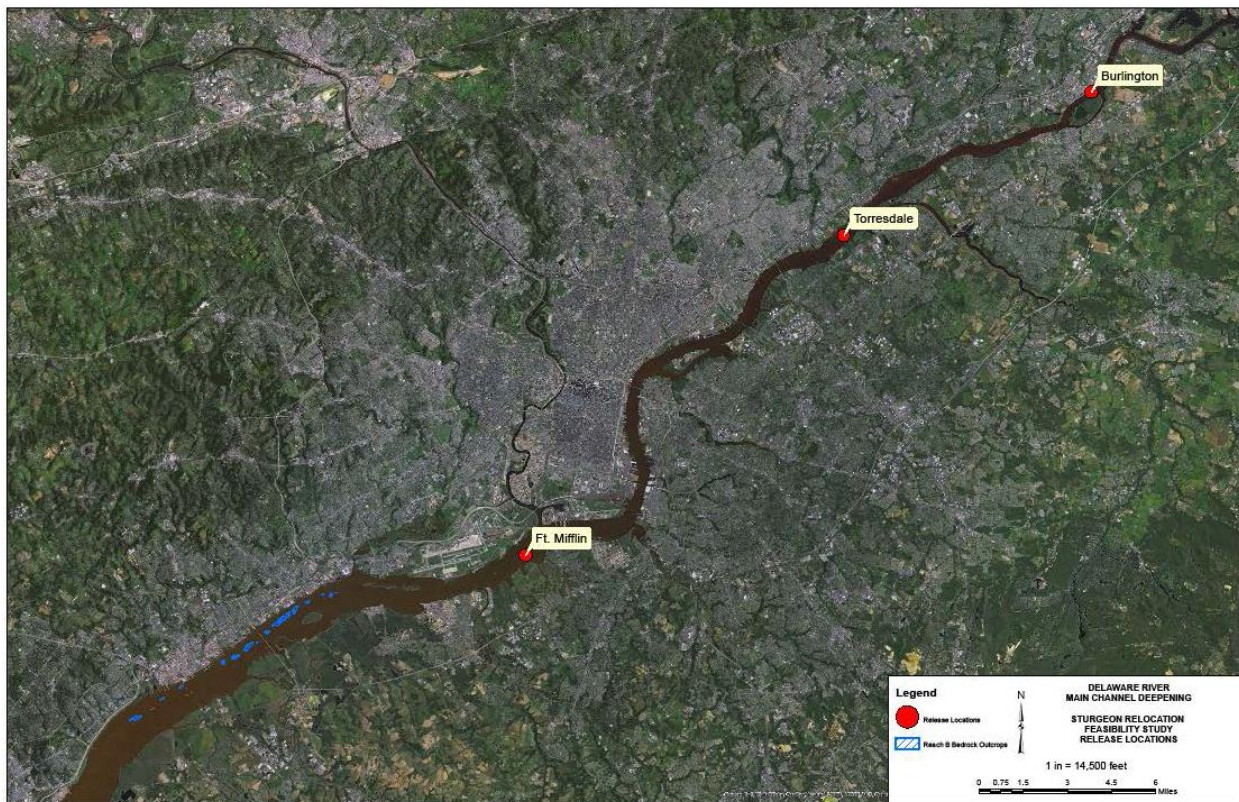


Figure 3: Sturgeon Release Locations from Brundage and O'Herron (2014a)

During the Brundage and O'Herron (2014a) study, two small sturgeon were injured during trawling; an Atlantic sturgeon (250 mm FL, 282 mm TL, 0.12 kg) collected on March 1, with a broken primary ray on its right pectoral fin and injury to its pectoral girdle (Fig. 14a), and a shortnose sturgeon (268 mm FL, 306 mm TL, 0.12 kg) taken on March 2, with injury to its pectoral girdle (Fig. 14b). Both injuries were likely caused by the sturgeon being crushed by tires or large woody debris in the net. Both injured sturgeon were released at Ft. Mifflin, but had difficulty maintaining equilibrium, and it is uncertain that they survived. Two injuries in 104 sturgeon captures equates to an injury rate of 1.9%. During transportation, a shortnose sturgeon (507 mm FL, 604 mm TL, 1.08 kg) died when it was inadvertently left in the transport tank. This accidental mortality was related to adverse and deteriorating weather conditions (significant wind and waves, heavy icing on the deck of the boat) that night and was not related to the transportation methodology itself. The researchers added additional procedures to ensure that this incident did not repeat.

ERC 2007 and Fisher 2011 (detailed above) demonstrate that there is natural movement between overwintering areas during the winter months. Brundage and O'Herron (2014a) demonstrate that it is possible to temporarily relocate overwintering sturgeon to other overwintering sites. This suggests that proposed movement of shortnose and Atlantic sturgeon collected at Marcus Hook to other areas where sturgeon are known to overwinter can be carried out without having an adverse impact on any individual. We expect there will be short term stress related to handling and relocation, however there are not likely to be any long term consequences to this (see above). Some pre-spawning adult shortnose sturgeon are expected to be captured at Marcus Hook; however, given the documented movement of relocated adults to the spawning grounds in the spring, we do not anticipate that the relocation will disrupt spawning migrations or otherwise disrupt pre-spawning activities or physiologies. Weather permitting, all sturgeon removed from Marcus Hook will be relocated to an area where overwintering has been documented; if weather and/or river ice prevents researchers from transporting the sturgeon to an established overwintering site, they will release the sturgeon as far upstream as possible from Marcus Hook. Because sturgeon are being relocated to areas known to support overwintering, we expect that sturgeon will have the environmental conditions and resources necessary to continue their overwintering behavior in the relocation areas. In the event that weather conditions prevent sturgeon from being relocated to a known overwintering area, we expect sturgeon to quickly move to suitable habitat. Based on this assessment, other than short term handling stress, we do not anticipate any negative effects to shortnose or Atlantic sturgeon moved from Marcus Hook to other documented overwintering areas.

7.4.4 *Acoustic Deterrence*

The purpose of the acoustic deterrent system will be to behaviorally deter sturgeon from entering or remaining in the blasting area. In July 2015, ERC (2015) conducted a feasibility study to test the acoustic deterrent system. Their analysis provided evidence that some sturgeon avoided the loudest portions of an experimental sound field and that sturgeon experienced no latent effects of the sound exposure. The study showed that sturgeon spent 4.55 hours less in the regions of interest when the sound was on than when the sound was off; however, the difference in time spent during test and control conditions was not statistically significant at the $\alpha = 5\%$ level. Regardless, there was some evidence of avoidance behavior, and the authors concluded that ensonifying the blast area would add a degree of protection to the sturgeon that cannot otherwise be accomplished.

The deterrent system will consist of a sound source capable of producing impulsive sound of the appropriate amplitude and frequency range, and a generator to power the source, mounted on a self-propelled pontoon boat. The sound source will be an Applied Acoustic Engineering Ltd. (AAE) "boomer" typically used for subsurface geophysical profiling (Moody and Van Reenan, 1967). The boomer is an electromagnetically driven sound source consisting of a triggered capacitor bank that discharges through a flat coil. Eddy currents are induced in aluminum plates held against the coil by heavy springs or rubber bumpers. The plates are violently repelled when the capacitor fires, producing a cavitation volume in the water which acts as a source of low-frequency sound (Edgerton and Hayward, 1964).

The sound source will be set to produce a sound level (as determined at 33 ft. (10 m) from the source) of ≤ 204 dB re 1 μ Pa peak at a repetition rate of 20/minute; it will also be mounted horizontally such that the sound is projected downward and laterally into the water column below the pontoon boat.

The sound source will be moored as closely to the blasting location as safety and operational considerations allow, and operated continuously for at least five hours prior to each detonation. The sound source will be operated as close in time to the blast as safety allows before being moved away from the blasting site (approximately 30 minutes).

Effects of Noise Produced During the Study

As noted above, the sound source will be set to produce a sound level of ≤ 204 dB re 1 μ Pa peak at a repetition rate of 20/minute for at least five hours prior to each detonation. Based on the results of the pilot study trials where the system operated at maximum energy (350 J), we expect peak noise to be 193 dB 1 μ Pa peak-to-peak (146 dB re 1 μ Pa single-pulse SEL) at a distance of 5.3 m from the sound source. The ensonified area will be approximately 0.4km², and all sturgeon behavioral responses are anticipated to occur within this ensonified area.

We expect potential injury to shortnose and Atlantic sturgeon upon exposure to impulsive noises greater than 206 dB re 1 μ Pa peak or 187 dB re 1 μ Pa cSEL. Peak noise levels will not exceed 193 dB re 1 μ Pa²·s peak and therefore will not exceed the peak noise exposure threshold of 206 dB re 1 μ Pa.

In addition to the “peak” exposure criteria, which relates to the energy received from a single impulse, the potential for injury exists for multiple exposures to lesser noise. That is, even if an individual fish is far enough from the source to not be injured during a single impulse, the potential exists for the fish to be exposed to enough less noisy impulses to result in physiological impacts. The cSEL criterion is used to measure such cumulative impacts. The cSEL is not an instantaneous maximum noise level, but is a measure of the accumulated energy over a specific period of time (e.g., the period of time it takes to install a specific structure, such as a pile). For the proposed action, the impulsive noise will be generated for five hours prior to each detonation (max of two detonations per day). The cSEL is calculated by incorporating both the noise level associated with a single impulse as well as the total number of noise events. In this instance, this would mean accounting for every impulse over the entire day (i.e., one impulse every 2 seconds for two five-hour periods, for a total of 18,000 impulses). We calculated that the distance to the 187 dB re 1 μ Pa cSEL isopleth is less than 5 meters from the noise source²¹. That means that in order to accumulate enough energy to be injured, a sturgeon would need to stay within 5 meters of the noise source for the entire 10 hour period that the system is operational. We do not expect this to happen because sturgeon in the Marcus Hook area are highly mobile. While some of the sturgeon tracked during the noise deterrent study did not avoid the ensonified area during the deterrent study, none of them were stationary for hours at a time. Therefore, it is not reasonable

²¹ Using the NMFS pile driving calculator (available at: www.wsdot.wa.gov/) and using a peak noise level of 193 dB, SEL of 146, and RMS of 178 (calculated by subtracting 15 from the peak as recommended by the authors of the calculator), all measured at a distance of 5.3 m from the sound source as described in ERC 2015.

to anticipate that any sturgeon would stay within 5 meters of the sound deterrent system for 10 hours. Based on this, we do not expect any injury or mortality to result from exposure to the noise produced by the deterrent system.

This conclusion is supported by the findings of ERC 2015. All of the sturgeon that were exposed to sound during ERC's 2015 tests were detected by multiple receivers in the weeks following testing. All of them showed normal patterns of movement, indicating that exposure to sound had not injured or impaired them. Based on the best available information (discussed above), it is extremely unlikely that any shortnose or Atlantic sturgeon will be exposed to injurious levels of underwater noise created by the deterrent device.

Impulsive noise will be experienced in a 0.4km² area. Here, we consider effects to shortnose and Atlantic sturgeon that leave and/or are excluded from the ensonified area. Because of the time of year, any sturgeon in the Marcus Hook area will be overwintering there. Here, we consider the effects of potentially disturbing sturgeon within this overwintering location.

Studies tracking the movements of juvenile sturgeon in the Delaware River indicate that individual behavior is diverse, with some individuals establishing a relatively small "home range" (see Fisher 2011) during the winter months and others exhibiting extensive movements. No information on what factors contribute to different behaviors is available; these differences are seen in fish of the same year class making it difficult to determine if there are environmental or developmental factors at play or if it is merely natural variability.

As noted above, ERC (2007) tracked four shortnose sturgeon and one Atlantic sturgeon; three of the shortnose sturgeon were tracked through the winter (one shortnose was only tracked from May – August 2006). Shortnose sturgeon 171 was located in the Baker Range in early January (rkm 83), and moved upriver to the Deepwater Point Range (rkm 105) in mid-January where it remained until it moved rapidly to Marcus Hook (rkm 130) on March 12. Shortnose sturgeon 2950 was tracked through February 2, 2007. In December, the fish was located in the Bellevue Range (rkm 120). Between January 29 and February 2, the fish moved between Marcus Hook (rkm 125) and Cherry Island (rkm 116). Shortnose sturgeon 2953 also exhibited significant movement during the winter months, moving between rkm 123 and 163 from mid-December through mid-March.

Fisher (2011) tagged and tracked juvenile, subadult and adult Atlantic sturgeon in the Delaware River in 2007, 2008 and 2009. All subadult and adult Atlantic sturgeon left the River by November and were not present in the river during the winter months. Young of the year sturgeon demonstrated highly variable behavior. From the mid-November to early March period, individuals either stayed within a small home range (less than 1 km) near the Marcus Hook anchorage (rkm 130) or made extensive movements (distances up to 50 km) between Philadelphia (rkm 154) and Roebing (rkm 199).

Based on the available information, juvenile Atlantic sturgeon and juvenile and adult shortnose sturgeon are likely to be exposed to impulsive noise during the testing of the sound deterrent. We expect these fish to react by leaving the area before underwater noise has an injurious cumulative

impact. Leaving the ensonified area would result in swimming less than 500 m. Sturgeon that avoid the ensonified area would move around it by potentially changing course by up to 500 m. Sturgeon that make evasive movements to avoid the area with disturbing levels of noise may experience increased energy expenditure. However, given the extremely small distance that would need to be traveled and given that these movements should be able to be made in less than a minute while swimming at normal, sustained or prolonged swim speeds, any increased metabolic cost is expected to be insignificant and will not cause any physiological stress to the fish. Based on this analysis, all effects to shortnose and Atlantic sturgeon from avoidance behavior will be insignificant and/or discountable.

While the sample sizes for the winter movement studies mentioned above are small, they demonstrate that there is natural movement between overwintering areas during the winter months. This suggests that movement of shortnose and Atlantic sturgeon within the general Marcus Hook area resulting from displacement from the ensonified area or even movement to another overwintering area would not have an adverse impact on any individual. We expect there will be a short term expenditure of energy associated with the movements, but this is likely to be well within their normal winter behaviors. As evidenced by the results of Brundage and O'Herron (2014a), displacement of pre-spawning adults will not affect the ability of these individuals to spawn successfully in the spring. No Atlantic sturgeon adults are expected to occur in the project area during the blasting window. All activities will cease by the time adults could be moving through the area in the spring, therefore, we do not expect any disruption of Atlantic sturgeon spawning migrations or otherwise disruptions of pre-spawning activities or physiologies. Based on this assessment, all effects to shortnose and Atlantic sturgeon will be insignificant.

7.4.5 Estimating Sturgeon Exposure to Blasting Noise

As explained above, in order to be injured or killed, a sturgeon would need to be within 500 feet of the detonation during the 15 second duration of the detonation. Up to two detonations per day will occur potentially everyday between December 1 and March 15. USACE will utilize measures to minimize the potential for blasting to occur if shortnose or Atlantic sturgeon are within 500 feet of the blast site. USACE will use a combination of far (passive and active acoustic monitoring) and nearfield (DIDSON) monitoring to determine if sturgeon are within a 500 foot radius of the blast site. Passive and active monitoring will be used to detect sturgeon in the general vicinity of the blasting area, allowing USACE to determine if sturgeon are likely to move close enough to the blast area to be at risk. Passive monitoring will be performed using 13 Vemco VR2W receivers, while active tracking will be conducted with a VEMCO VR100 receiver. The DIDSON is a multi-beam sonar "acoustic camera." The 500 foot radius on the blast site will be monitored using the DIDSON starting 1-2 hours and ending 15 minutes before each detonation. If a sturgeon is observed, the blasting contractor will be advised by USACE to delay the shot until the sturgeon has moved safely away.

As noted above, as part of the Brundage and O'Herron (2014a) winter trawling and relocation study, the authors tagged 26 juvenile Atlantic sturgeon and 62 juvenile and adult shortnose sturgeon captured in Marcus Hook (rkm 127-139). These fish were relocated to upriver release locations (30 at Ft. Mifflin (rkm 147), 27 at Torresdale (rkm 176) and 31 at Burlington (rkm

193). Researchers tracked these fish and determined whether they returned to Marcus Hook and if so, how long it took to return. Seventeen of 26 Atlantic sturgeon returned to Marcus Hook, moving back within 0.7-48.4 days (mean of 18.6 days). Forty-nine of 62 shortnose sturgeon returned to Marcus Hook, moving back within 0.4-54.2 days to return (mean of 18.3 days). Based on this, we expect that by carrying out relocation trawling every other day, USACE will significantly reduce the number of sturgeon in the Marcus Hook area during the blasting period.

While relocated sturgeon may return to the blast site, relocation trawling is an effective method to temporarily remove sturgeon from the area and reduce the number of sturgeon that could be exposed to the detonations. In the pilot study, sturgeon that traveled back to the Marcus Hook area took an average of 18 days to return. During this project, USACE will use passive acoustic receivers to track whether or not tagged sturgeon are moving back toward the blast area which will allow adjustments to be made to the trawl schedule if sturgeon are moving back to the area more quickly than anticipated. At the blast site, active acoustic monitoring will alert USACE to the presence of any tagged sturgeon in the area, while the DIDSON is effective at identifying sturgeon (including those which are not tagged). In addition, the acoustic deterrent, described in section 7.4.4, may act as a behavioral deterrent to at least some sturgeon and reduce the number of sturgeon in a 500 meter radius around the detonation site.

Taking all of the sturgeon protection measures into account, we do not expect any sturgeon to be in the blast area (i.e., the 500-foot radius surrounding the detonation) during the 15 second detonation period. This is because: (1) the relocation trawling will reduce the number of sturgeon in the Marcus Hook area as it will result in sturgeon being physically moved from the area; (2) relocation trawling will be done often enough to maintain the reduction in numbers of sturgeon in the Marcus Hook area and the frequency will be adjusted as necessary based on movements of tagged sturgeon; (3) the noise deterrent system will produce potentially bothersome levels of noise in an area approximately three times the size of the blast area for five hours prior to the detonation (shut off 15 minutes before the detonation), this could act as a behavioral deterrent for at least some sturgeon and further reduce the number of sturgeon in the blast area; (4) active tracking of tagged sturgeon in the blast area will allow USACE to determine if any tagged sturgeon are in the blast area and to delay the detonation until the area is clear; while this will not allow detection of untagged sturgeon it will further reduce the number of sturgeon potentially exposed to the detonation; (5) DIDSON imaging will be used to detect the presence of fish in the blast area up until 15 minutes before the detonation occurs; if any targets that appear to be sturgeon are detected, the detonation will be delayed until the area is clear, while the DIDSON is not 100% accurate at detecting sturgeon, it provides an additional layer of protection. These factors together, will minimize the potential for sturgeon to occur in the blast area during a detonation. Lastly, two scare charges shall be used before each blast. The scare charges shall be detonated in close proximity to each blast. Each individual scare charge shall not exceed a TNT-equivalent weight of 0.1 lb. The detonation of the first scare charge will be 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. It is expected that any remaining fish will leave the 500 foot radius of the blast following the scare charges, and that none will reenter the area before the detonation. Outside of the 500 foot zone, no effects to fish are likely (USACE 2008 and USACE 2009). Because of these protection measures, and

given the extremely short duration of the actual detonation (i.e., 15 seconds), we do not expect any sturgeon to be close enough to the detonation to be injured or killed.

After blasting is completed, mechanical dredging will be used to remove displaced rock debris. In rare occurrences shortnose 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. However, captures of shortnose and Atlantic sturgeon have been documented in the Kennebec River, Maine. It is unknown if this is due to a unique situation in this river or if captures of sturgeon occur at other projects that have not had the same level of observer coverage and that the intense observer coverage at dredging operations in this river has allowed detection here. 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 removing debris following blasting. Monitoring has been ongoing at dredging projects associated with the Tappan Zee Bridge replacement project on the Hudson River. The first stage of dredging occurred in 2013. Two dredges were used between August 2 and October 30, 2013 and a total of 844,120 cy of material were removed using a bucket dredge. NMFS-approved observers were present to monitor 100% of all dredging. All dredge observer forms were submitted to us on December 31, 2013. While fish and other biological materials were observed in 279 loads (out of approximately 1,500), no shortnose or Atlantic sturgeon were observed. Dredging occurred again in 2015 with approximately 150,000 cy of material removed; observer coverage was 100% and no shortnose or Atlantic sturgeon were observed. The area where dredging occurred is a high use area for shortnose and Atlantic sturgeon.

Due to the relatively low level of risk that an individual 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 per blasting season when mechanical dredging is used for debris removal. Sturgeon captured in a 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, one Atlantic), one of the shortnose sturgeon was killed. This fish suffered from a large laceration, likely experienced due to contact with the dredge bucket. As the risk of mortality once captured is high, it is reasonable to expect that both the shortnose and Atlantic sturgeon likely to be captured in the dredge bucket could suffer injury or mortality due to contact with the dredge bucket or through suffocation due to burial in the scow.

In summary, removal of debris with a mechanical dredge (following blasting) is likely to result in injury or mortality to no more than two Atlantic sturgeon and two shortnose sturgeon (one of each species per blasting season). The affected shortnose sturgeon could be juveniles or adults. Affected Atlantic sturgeon could be YOY or juveniles. Based on tracking studies conducted to date, during the time of year that blasting and debris removal will occur, we anticipate that the Atlantic sturgeon in the Marcus Hook area will be young of year or juveniles. These young of year and juveniles will be Delaware River origin and from the New York Bight DPS. We do not anticipate any subadult or adult Atlantic sturgeon will be present in the Marcus Hook area during

the time of year when blasting and debris removal will occur.

7.6 Effects on Benthic Resources and Foraging

7.6.1 Dredging

7.6.1.1 Effects to Sea Turtles

Since dredging involves removing the bottom material down to a specified depth, the benthic environment will be impacted by dredging operations. No sea grass beds occur in the areas to be dredged with a hopper dredge; therefore, green sea turtles will not use the areas as foraging areas. Thus, we anticipate that the dredging activities are not likely to disrupt normal feeding behaviors for green sea turtles. Records from previous dredge events occurring in the lower channel indicate that some benthic resources, including whelks, horseshoe crabs, blue crabs and rock crabs are entrained during dredging. Other sources of information indicate that potential sea turtle forage items are present in the channel, including jellyfish, clams, mussels, sea urchins, whelks, horseshoe crabs, blue crabs and rock crabs (USACE 1997, 2009).

Of the listed species found in the action area, loggerhead and Kemp's ridley sea turtles are the most likely to utilize the channel areas for feeding with the sea turtles foraging mainly on benthic species, namely crabs and mollusks (Morreale and Standora 1992, Bjorndal 1997). As noted above, suitable sea turtle items occur in the channel. As preferred sea turtle and sturgeon foraging items occur at the channel areas and depths are suitable for use by sea turtles, some foraging by these species likely occurs at these sites.

Dredging can cause indirect effects on sea turtles by reducing prey species through the alteration of the existing biotic assemblages. Kemp's ridley and loggerhead sea turtles typically feed on crabs, other crustaceans and mollusks. Some of the prey species targeted by turtles, including crabs, are mobile; therefore, some individuals are likely to avoid the dredge; however, there is likely to be some entrainment of sea turtle prey items. The Delaware River estuary is approximately 700 square miles. The Philadelphia to the Sea navigation channel is approximately 15.3 square miles. USACE has estimated that approximately 8.5 square miles will be dredged (approximately 55% of the existing channel, or 1.2% of the estuary) with no more than 0.33% of the estuary dredged in a particular year. While there is likely to be some reduction in the amount of prey in the channel areas, the area affected is small (i.e., less than 1% of the estuary annually) and the action will result in the loss of only a portion of the available forage in the dredged area.

Depending on the species, recolonization of a dredged channel can begin in as short as a month (Guerra-Garcia and Garcia-Gomez 2006). The dredged area is expected to be completely recolonized by benthic organisms within approximately 12 months (USACE 2001, US DOI 2000). These conclusions are supported by the conclusions of a benthic habitat study which examined an area of Thimble Shoal following dredging and concluded that recolonization of the dredged area was rapid with macrobenthic organisms abundant on the first sampling date following cessation of dredging activities (less than a month later).

The placement of sand at the beneficial use sites may affect benthic resources in those areas. Mobile organisms, such as crabs are expected to be able to avoid the area where material is being deposited. Concern has been raised that the deposition of material on these beaches could affect spawning horseshoe crabs which sea turtles eat. Spawning occurs during the full and new moons in May and June and peaks during evening high tides. Material will be deposited at Broadkill Beach in September – April and at Oakwood Beach between September and March; given the time of year, it is unlikely that these activities will affect spawning horseshoe crabs. Material will be deposited on Kelly Island between April and August; therefore there is the potential for dredged material disposal to overlap with horseshoe crab spawning; however, due to erosion at this beach it is not thought to be a constant or consistent spawning site (Weber 2001). Restoration of both of these beaches with dredged material will restore beach area and is likely to increase the future potential for supporting spawning horseshoe crabs.

Based on this analysis, while there will be a small reduction in sea turtle prey due to dredging, these effects will be insignificant to foraging loggerhead and Kemp’s ridley sea turtles. No effects to the prey base of green or leatherback sea turtles are anticipated.

Shortnose and Atlantic sturgeon feed on a variety of benthic invertebrates. One of the major potential food sources for shortnose sturgeon is the Asiatic river clam (*Corbicula manilensis*) as this shellfish is very abundant (Brundage, pers. Communication, 2014). While shortnose sturgeon feed on shellfish and other benthic invertebrates, shellfish typically make up a very small percentage of the prey base of Atlantic sturgeon; Atlantic sturgeon prey primarily on soft bodied invertebrates such as worms (Guilbard et al. in Munro et al. 2007; Savoy in Munro et al. 2007). The proposed dredging is likely to entrain and kill at least some of these potential forage items. Given the limited mobility of most benthic invertebrates that sturgeon feed on, most are unlikely to be able to actively avoid the dredge. Benthic sampling done by O’Herron and Hastings (1985) in association with past USACE maintenance dredging in the Delaware River found that *Corbicula* recolonized the dredge areas during the subsequent growing season. However, the post-dredge individuals collected were smaller than pre-dredge individuals and provided less biomass. O’Herron and Hastings (1985) found that adult shortnose sturgeon may not be able to efficiently utilize new molluscan colonizers due to the limited biomass until the end of the second growing season after dredging. Based on this information, sturgeon should only be exposed to a reduction in forage in the areas where dredging occurs for one to two seasons immediately following dredging. As explained above for sea turtles, the area dredged in any particular year is a very small percentage of the available foraging habitat in the river. Because effects to benthic prey will be limited to the area immediately surrounding the dredged area, the potential for disruption in foraging is low. Brundage (1985) and Hatin *et al.* (2007) both found that sturgeon were more common outside of the deepwater channel, which suggests that loss of forage items within the channel would have an insignificant effect on these species.

7.6.2 *Blasting*

Shortnose sturgeon generally feed when the water temperature exceeds 10°C and in general, foraging is heavy immediately after spawning in the spring and during the summer and fall, with lighter foraging during the winter (USACE 2000, NMFS 1996). The likelihood that shortnose sturgeon are actively foraging in the area where blasting will occur is low, but shortnose sturgeon

could still be feeding in the vicinity of the blasting. The foraging habits of Atlantic sturgeon in the Marcus Hook area are unknown, but it is presumed that some foraging occurs in this area. As noted above, Asiatic river clams are a significant portion of the prey base of shortnose sturgeon in the Delaware River. Fine clean sand, clay, and coarse sand are preferred substrates for this clam, although this species may be present in lower numbers on almost any substrate (Gottfried and Osborne 1982, Belanger *et al.* 1985, Blalock and Herod 1999). The substrate in the area proposed for blasting is primarily rock and is not expected to be a concentration area for this prey species, but *Corbicula* has been found on gravel and bedrock substrates in the Susquehanna River. Few other benthic invertebrates are present in the rocky area where blasting will occur. However, any prey species that is present on the rock that will be removed by blasting or in the immediate project area would be destroyed. The impact should not extend beyond the immediate blasting area as previous studies indicate that invertebrates are relatively insensitive to pressure related damage from underwater detonations (USACE 2000). This could be attributable to the fact that all the invertebrate species tested lack gas-containing organs, which have been implicated in internal damage and mortality in vertebrates (Keevin and Hempen 1997). Nevertheless, the area immediately surrounding the blast zone would be void of preferred sturgeon prey and thus, sturgeon would not be likely to forage in this area.

It is important to note, however, that while blasting will destroy all of the prey resources in the immediate area, the impacts will not be permanent and as discussed above for dredging, the benthic community will likely reestablish within two years. The area where blasting will occur is very small; representing only approximately 1% of the channel area and even smaller percentage of the area where foraging is known to occur.

We anticipate that while the dredging activities may temporarily disrupt normal feeding behaviors for sea turtles and sturgeon by causing them to move to alternate areas, the action is not likely to remove critical amounts of prey resources from the action area and any disruption to normal foraging is likely to be insignificant. Additionally, as (1) the area to be affected by dredging and blasting is small; (2) few motile organisms will be affected by the proposed dredging (3), recolonization of the benthic community will be rapid and complete within 2 years; and, (4) the same area will not be dredged more frequently than once every few years, we have determined that any effects to foraging sea turtles and sturgeon will be temporary and insignificant.

7.7 Dredge and Disposal Vessel Traffic

There have not been any reports of dredge vessels colliding with listed species but contact injuries resulting from dredge movements could occur at or near the water surface and could therefore involve any of the listed species present in the area. Because the dredge is unlikely to be moving at speeds greater than three knots during dredging operations, blunt trauma injuries resulting from contact with the hull are unlikely during dredging. It is more likely that contact injuries during actual dredging would involve the propeller of the vessel. Contact injuries with the dredge are more likely to occur when the dredge is moving from the dredging area to port, or between dredge locations. While the distance between these areas is relatively short, the dredge in transit would be moving at faster speeds than during dredging operations, particularly when empty while returning to the borrow area.

The dredge vessel may collide with sea turtles when they are at the surface. These species have been documented with injuries consistent with vessel interactions and it is reasonable to believe that the dredge vessels considered in this Opinion could inflict such injuries on sea turtles, should they collide. As mentioned, sea turtles are found distributed throughout the action area in the warmer months, generally from May through mid-November.

Interactions between vessels and sea turtles occur and can take many forms, from the most severe (death or bisection of an animal or penetration to the viscera), to severed limbs or cracks to the carapace which can also lead to mortality directly or indirectly. Sea turtle stranding data for the U.S. Gulf of Mexico and Atlantic coasts, Puerto Rico, and the U.S. Virgin Islands show that between 1986 and 1993, about 9% of living and dead stranded sea turtles had propeller or other vessel strike injuries (Lutcavage *et al.* 1997). According to 2001 STSSN stranding data, at least 33 sea turtles (loggerhead, green, Kemp's ridley and leatherbacks) that stranded on beaches within the northeast (Maine through North Carolina) were struck by a vessel. This number underestimates the actual number of vessel strikes that occur since not every vessel struck turtle will strand, every stranded turtle will not be found, and many stranded turtles are too decomposed to determine whether the turtle was struck by a vessel. It should be noted, however, that it is not known whether all vessel strikes were the cause of death or whether they occurred post-mortem (NMFS SEFSC 2001).

Information is lacking on the type or speed of vessels involved in turtle vessel strikes. However, there does appear to be a correlation between the number of vessel struck turtles and the level of recreational boat traffic (NRC 1990). Although little is known about a sea turtle's reaction to vessel traffic, it is generally assumed that turtles are more likely to avoid injury from slower-moving vessels since the turtle has more time to maneuver and avoid the vessel. The speed of the dredge is not expected to exceed 3 knots while dredging or while transiting to the pump out site with a full load and it is expected to operate at a maximum speed of 10 knots while empty. In addition, the risk of vessel strike will be influenced by the amount of time the animal remains near the surface of the water. For the proposed action, the greatest risk of vessel collision will occur during transit between shore and the areas to be dredged. The presence of an experienced endangered species observer who can advise the vessel operator to slow the vessel or maneuver safely when sea turtles are spotted will further reduce the potential risk for interaction with vessels. The addition of one to two slow moving vessels in the action area has an insignificant effect on the risk of interactions between sea turtles and vessels in the action area.

Available information on the risk of vessel operations to shortnose sturgeon is discussed in the Environmental Baseline section above. Aside from the incidents discussed there, 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, we have considered the likelihood that an increase in vessel traffic associated with dredging, blasting and disposal would increase the risk of interactions between shortnose sturgeon and vessels in the action area. Approximately 3,000 cargo vessels transit the Delaware River annually as well as numerous smaller commercial and recreational vessels. Dredging, blasting and disposal for

deepening and maintenance of the deepened channel is likely to result in an increase of one to two slow moving vessels during the times when project operations are ongoing (typically a 2-3 month period each year). Based on the high ship traffic currently experienced in the action area, it is unlikely that an increase of only one to two slow moving vessels per day would increase the risk of interactions between shortnose sturgeon and vessels operating in the Delaware River generally. As such, the increase in risk is likely to be insignificant and interactions between project vessels and shortnose sturgeon are extremely unlikely to occur (the effects of deepening on the use of the channel by vessels is analyzed in section 7.12, below).

Information regarding the risk of vessel strikes to Atlantic sturgeon is discussed in the Status of the Species and Environmental Baseline sections above. As explained there, we have limited information on vessel strikes and many variables likely affect the potential for vessel strikes in a given area. Assuming that the risk of vessel strike increases with an increase in vessel traffic, we have considered whether an increase in vessel traffic in the action area during dredging, blasting and disposal (one to two slow moving vessels per day) would increase the risk of vessel strike for Atlantic sturgeon in this area. Given the large volume of traffic on the river and the wide variability in traffic in any given day, the increase in traffic of one to two vessels per day is negligible and the increased risk to Atlantic sturgeon is insignificant. We have no information indicating that there has been any increase in vessel strikes to any species since the deepening project began.

7.8 Effects of Deepening on Substrate/Habitat Type

During the consultation process, we requested information on the potential of the proposed deepening to alter the substrate type in areas to be dredged. If substrate type was altered, the benthic community that recolonizes the dredged area could be fundamentally different than the original community and this could affect the availability of forage items for listed species. However, USACE has indicated that the remaining sub-surface strata below the dredging pay-prism is consistent with the maintenance material removed during a typical dredging operation. The maintenance material removed from this project historically consists of a mixture of sand and mud. Typical material densities vary in range from silt/mud between 1137 (g/l) to 1337 (g/l) and sands 1526 (g/l) to 1874 (g/l). USACE has indicated that the same ratio is anticipated as a result of the deepening project and that no alterations in the type of sediment occurring in the dredged areas will result from the proposed action. USACE has also indicated that while blasting within the Marcus Hook area will remove bedrock, it is only removing enough rock to deepen the area to 45 feet. Because only the top layers of the rock will be removed, and the bedrock extends deep into the river bottom, rock will remain in all areas where blasting will occur.

At our request, USACE conducted sediment sampling both before and after deepening occurred in Reach B (USACE 2012). These reports confirmed that sediment type was unchanged after deepening.

Based on the information provided by USACE and confirmation sampling that has occurred to date, no changes in substrate type are anticipated to result from dredging. Effects to forage items are considered in section 7.5 and effects to Atlantic sturgeon spawning are considered in section 7.9.

7.9 Effects of Deepening on Salinity

Salinity is the concentration of inorganic salts (total dissolved solids, or "TDS") by weight in water, and is commonly expressed in units of "psu" (practical salinity units) or "ppt" (parts per thousand). By example, ocean water with a salinity of 30 ppt contains ~30 grams of salt per 1,000 grams of water. As explained above, the action area experiences a wide variety of salinity influenced by multiple factors. Also as explained above, the salinity gradient effects the distribution of listed species in the action area with sea turtles less likely to occur as salinity decreases and shortnose sturgeon more prevalent in the low salinity reaches. Concerns have been raised that the proposed deepening could alter the salinity regime in the estuary.

7.9.1 Existing Salinity Conditions in the Delaware River

The distribution of salinity in the Delaware estuary exhibits significant variability on both spatial and temporal scales, and at any given time reflects the opposing influences of freshwater inflow from tributaries (and groundwater) versus saltwater inflow from the Atlantic Ocean. Saltwater inflow from the ocean is in turn dependent on the tidal discharge and the ocean salinity. Salinity at the bay mouth typically ranges from about 28 to 32 ppt. Tributary inflows by definition have "zero" salinity in the sense of ocean-derived salt; however, these inflows contain small but finite concentrations of dissolved salts, typically in the range of 100 to 250 parts per million (ppm) or from 0.1 to 0.25 ppt TDS.

A longitudinal salinity gradient is a permanent feature of salt distribution in the Delaware estuary. That is, salinity is always higher at the mouth and downstream end of the system and decreases in the upstream direction. The upstream limit of ocean-derived salinity is customarily treated as the location of the 0.5 ppt (or 500 ppm) isohaline. For purposes of monitoring water quality in the Philadelphia-Camden area, the DRBC has adopted the 7-day average location of the 250 ppm isochlor as the "salt line." Because chloride ions represent approximately 55% by weight of the total dissolved ions in seawater, a "salt line" defined by a chlorinity of 250 ppm approximates a salinity of 450 ppm, or 0.45 ppt.

There is also a lateral salinity gradient present in the bay portion of the estuary, between the mouth and about rkm 80, with higher salinities near the axis of the bay, and lower salinities on the east and west sides. Upstream of Artificial Island at rkm 80, salinity tends to be more uniformly distributed across the channel. Under most conditions in the estuary, there is only a small vertical salinity gradient, due to the dominance of tidal circulation and mixing relative to the normal freshwater inflow. However, under prolonged high-flow conditions, such as during the spring freshet, vertical salinity gradients of as much as 5 ppt can occur in the lower bay, with corresponding smaller vertical gradients at locations further upstream to the limit of the salt line. At any given point in the estuary between the bay mouth and the location of the salt line, the salinity of the water column will vary directly with the phase of the tidal currents. Maximum salinity at a point occurs around the time of slack water after high tide, and minimum salinity occurs at the time of slack after low. This condition reflects the significant role played by tidal currents in advecting higher salinity water in the upstream direction during flood flow, with lower salinity water being advected in the downstream direction during ebb. For periods longer than a single tidal cycle, the salinity at a given location varies in response to other important

forcing functions, including the short-term and seasonal changes in freshwater inflow, wind forcing over the estuary and adjacent portions of the continental shelf, and salinity and water level changes at the bay mouth. Over longer periods (years to decades and longer), sea level changes and modifications to the geometry of the estuary also affect the long-term patterns of salinity distribution.

To illustrate the variability of salt distribution in the estuary over time, Figure 4 presents a plot of the “salt line” location within Delaware estuary, along with average daily inflow at Trenton, for the period 1 January 1998 through 30 November 2008 (10.9 years). The term “salt line” refers to the 7-day average location of the 250 mg/l (ppm) isochlor (equivalent to 0.45 ppt salinity), and is used as an approximate indicator of the upstream penetration of ocean-derived salinity. In the ~11-year period shown, the salt line has been as far north as rkm 145 in late summer 2005, and at or below rkm 64 during multiple high-flow periods in 2006, a range that exceeds 80 km along the axis of the estuary for a period just over a decade. Figure 5 is a histogram of the daily salt line location for the same January 1998 to November 2008 period, and shows that the average location over this period is about rkm 114, upstream of the Delaware Memorial Bridge and near the mouth of the Christina River in Wilmington, Delaware. Based on monthly averages, the salt line maximum penetration occurs in October (rkm 130) with the minimum in April (rkm 98), reflecting the typical seasonal pattern of freshwater discharge to the estuary. A general observation is that the salt line location varies directly with the volume of freshwater inflow, and is located in the 32 kilometer long zone between rkm 98 and 130 during an “average” year.

The four longitudinal salinity zones within the Delaware Estuary, starting at the downstream end, are referred to as: polyhaline (18 - 30 ppt) from the mouth of the bay to the vicinity of the Leipsic River (RM 34); mesohaline (5 - 18 ppt) from the Leipsic River to the vicinity of the Smyrna River (RM 44); oligohaline (0.5 - 5 ppt) from the Smyrna River to the vicinity of Marcus Hook (RM 79), and fresh (0.0 - 0.5 ppt) from Marcus Hook to Trenton. Although these zones are useful to describe the long-term average distribution of salinity in the estuary, the longitudinal salinity gradient is dynamic and subject to short and long-term changes caused by variations in freshwater inflows, tides, storm surge, weather (wind) conditions, etc. These variations can cause a specific salinity value (isohaline) to move upstream or downstream by as much as 16 km in a day due to semi-diurnal tides, and by more than 32 km over periods ranging from a day to weeks or months due to storm and seasonal effects on freshwater inflows.

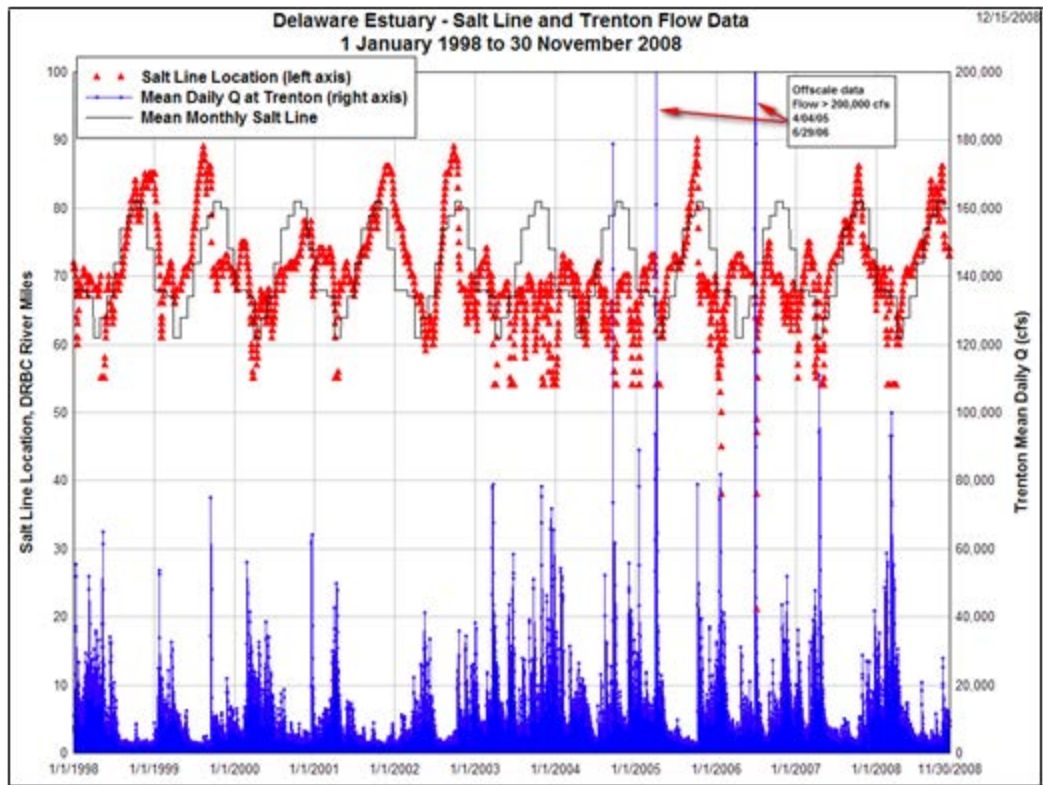


Figure 4: Salt Line Location and Trenton Inflows from 1998 to 2008. (from USACE 2009)

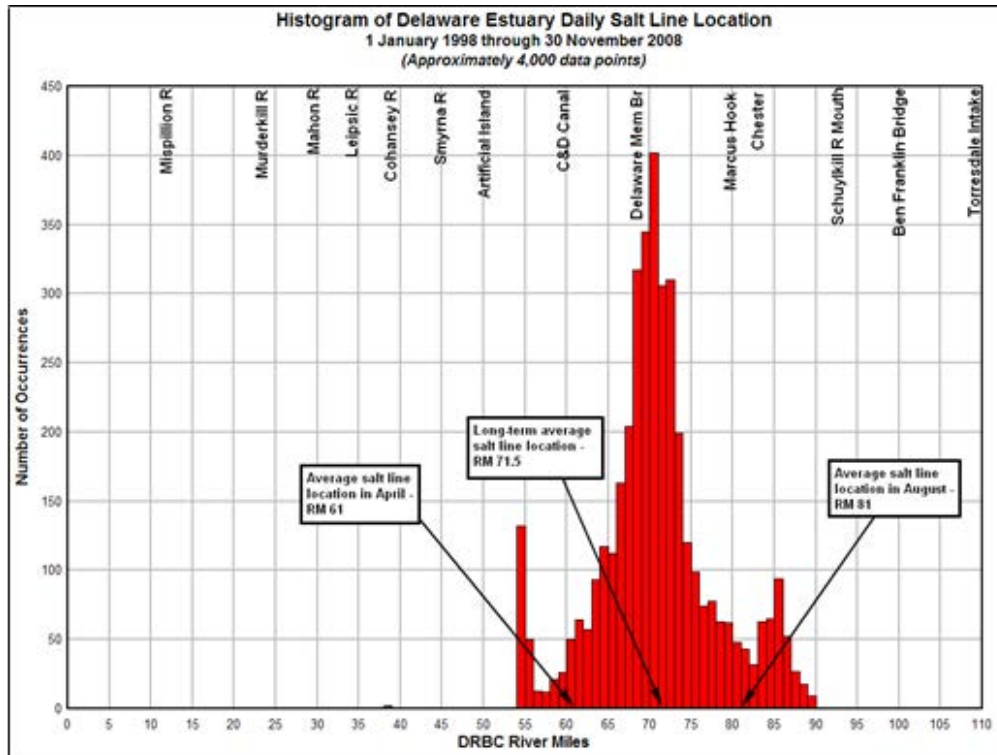


Figure 5: Histogram of Salt Line Location 1998-2008 (from USACE 2009)

7.9.2 Projected Changes in Salinity

USACE has conducted several models to estimate any modifications to the salinity regime that could result from deepening.

In order to estimate the potential for the proposed channel deepening to affect salinity distribution, USACE applied the 3-D numerical hydrodynamic model “CH3D-WES” (Curvilinear Hydrodynamics in Three Dimensions) to develop data on the movement of the salt line and the 5, 10, and 15 ppt isohalines that cover various locations in the estuary and correspond to salinities significant to various components of the estuarine ecosystem.

CH3D-WES includes as input data (“boundary conditions”) the most important physical factors affecting circulation and salinity within the modeled domain. As its name implies, CH3D-WES makes computations on a curvilinear, or boundary fitted, planform grid. Physical processes affecting baywide hydrodynamics that are modeled include tides, wind, density effects (salinity and temperature), freshwater inflows, turbulence, and the effect of the earth's rotation. The representation of vertical turbulence is crucial to a successful simulation of stratification in the bay. The boundary fitted coordinates feature of the model provides enhancement to fit the scale of the navigation channel and irregular shoreline of the bay and permits adoption of an accurate and economical grid schematization. The vertical dimension is Cartesian which allows for modeling stratification on relatively coarse horizontal grids.

The principal goal of the modeling effort was to identify and quantify any impacts of the proposed 5-foot channel deepening on spatial and temporal salinity distribution. A number of modeling scenarios were developed to represent a range of boundary and forcing conditions of potential importance to both human and non-human resources of the Delaware Estuary. Several scenarios were identified and selected for application in the 3-D model to address the impact of channel deepening on salinity distribution and subtidal circulation in the Delaware Estuary. The selection of these sets of conditions was based on coordination accomplished through interagency workshops.

The selected scenarios include:

1. The June-November 1965 drought of record, with Delaware River discharges adjusted to reflect the existing reservoir regulation plan and corresponding flows ("Regulated 1965");
2. Long-term monthly-averaged inflows with June-November 1965 wind and tide forcings; and
3. A high-flow transition period, represented by the April-May 1993 prototype data set.

Each of these periods was simulated first with the existing 40 foot navigation channel, and then with the proposed 45 foot channel in place. Based on these model results, the USACE concluded that while deepening would result in salinity increases in the Philadelphia area during a recurrence of the drought of record, these increases would be small. The model estimates that the 10 ppt isohaline, which can fluctuate naturally over a 48 km zone of the estuary, moved upstream an average of from 0.0 to 1.6 km with the deepened channel. The maximum monthly average increase in salinity within the mesohaline zone was 0.1 to 0.3 ppt.

Updated modeling was conducted in 2003 to consider effects of deepening in conjunction with other factors that were likely to increase salinity. Section 4.1.2.3 of the 2009 EA reports salinity modeling results from simulation of the 1965 drought of record with a channel deepened to 45 feet, DRBC projected 2040 consumptive use and a 2040 sea level rise projection based on NOS tide gauge data collected during the 20th century along the coasts of New Jersey and Delaware. Results are reported at the Delaware Memorial Bridge (RM 69 (Rkm 111)), Chester, PA (RM 83 (rkm 134)) and the Ben Franklin Bridge (RM 100 (rkm 161)) (Table 4-1 of the April 2009 EA). Modeling results are provided for each scenario (deepened channel, 2040 consumptive use, 2040 sea level rise) and for the three scenarios combined. Results are the peak 7-day-average change in salinity resulting from each scenario compared with the background range of salinity during the 1965 simulation period.

At the Delaware Memorial Bridge, background salinity for the 1965 drought of record ranged from 0 to 6 ppt. The projected peak 7-day average increase for the three combined scenarios is 0.9 ppt; resulting in a projected salinity level during worst case drought conditions of 0.9- 6.9 ppt. At Chester, PA, background salinity for the 1965 drought of record ranged from 0 to 1.8 ppt. The projected peak 7-day-average increase for the three combined scenarios is 0.3 ppt; resulting in a projected salinity level during worst case drought conditions of 0.3-2.1 ppt. At the Ben Franklin Bridge, background salinity for the 1965 drought of record ranged from 0 to 0.3 ppt. The projected peak 7-day-average increase for the three combined scenarios is 0.036 ppt;

resulting in a projected salinity level during worst case drought conditions of 0.036 – 0.336 ppt. Projected salinity increases resulting from a deepened channel, 2040 consumptive use and 2040 sea level rise would continue to decrease moving upstream.

As part of their analysis, Ross *et al.* (2015) considered the impact of the Delaware deepening project on salinity trends at Chester (RM 83.6 in Reach B) and found that the effect of recent deepening has not influenced long-term salinity trends. Furthermore, the authors cite Kim and Johnson (2007), stating that the impact of sea level rise will increase salinity more than channel deepening and water consumption combined.

7.9.3 Effects of Salinity Changes on sturgeon

Changes in salinity could affect the distribution of shortnose and Atlantic sturgeon in the river. In the Delaware River, subadult Atlantic sturgeon are known to congregate and overwinter within brackish river waters (Brundage and Meadows, 1982). Previous studies have noted that subadult Atlantic sturgeon typically occupy both the oligohaline and moderately mesohaline (<10ppt) environments (Dovel and Berggren, 1983; Kiefer and Kynard, 1993; Moser and Ross, 1995; Simpson, 2008). For both of these species, early life stages (i.e., eggs and larvae) have little to no tolerance to salinity and therefore, spawning occurs in fresh water. Tolerance to salinity increases with age and size (Jenkins *et al.* 1993, McEnroe and Cech 1985). During at least the first year, shortnose and Atlantic sturgeon are limited in distribution to fresh water; as a result their distribution is typically upstream of the “salt wedge.” If the salt wedge moved further upstream, there could be a reduction in available spawning or rearing habitat.

Based on seasonal movements of tagged adults in conjunction with habitat data, Atlantic sturgeon spawning in the Delaware River is thought to occur between rkm 120-150 and 170-190 in areas where salinity is around 0.5 ppt (Breece 2011). In April, the average salt line location (measured as 0.25 ppt) is rkm 98; in August the average salt line location is rkm 130. Near rkm 161, salinity could peak at 0.336 ppt. It is important to note that the deepening of the channel is only one factor contributing to this increase in salinity and that it causes only about 25% of this increase. The primary factor is expected sea level rise.

Salinity near rkm 161 peaks around 0.3 ppt even during drought conditions; this is within the range where spawning and rearing can occur. The expected increase in 2040, even under the worst conditions, is only 0.036 ppt, which would not increase salinity enough to cause it to be no longer suitable for spawning. Based on the model results, it is unlikely that the increase of salinity at rkm 161 and further upstream would affect the selection of spawning sites or the success of development of any eggs or larvae in this area. Thus, the potential for spawning at the rkm 170-190 site is likely to be unaffected due to effects of the deepening project on salinity.

Modeling discussed above indicates that in 2040, with deepening and predicted increases in consumptive water use and sea level rise, salinity near Chester (rkm 134) could be approximately 0.3ppt higher than it is now during worst case drought conditions and would peak at 2.1ppt rather than the historical high of 1.8ppt; deepening accounts for 0.07 ppt of the 0.3 ppt increase in salinity. In meteorologically average years, the spawning location of rkm 120-150 is within the 32 km average range of the spring/summer location of the 0.45 ppt salt line (rkm 98-

130) and located just upstream of the long-term average salt line location (rkm 115). A predicted increase in salinity due to the deepening of 0.07 ppt in this area (i.e., near the modeled point of Chester, rkm 134) would still be within the range (approximately 0.5 ppt) where spawning is expected to occur. This increase in salinity is not likely to affect the selection of spawning sites or the success of development of eggs or larvae in this area.

During extremely dry years, such as the record drought year of 1965, salinity in at least portions of the rkm 120-150 spawning area may be too high to support the development of eggs and larvae (1.8 ppt). When sea level rise and increases in consumptive water use are considered, the increase in salinity in this area could be as much as 0.3 ppt during worst case drought conditions. Given the small increase in salinity caused by the deepening, the deepening would not exacerbate these conditions or cause these areas to be unsuitable more often than they have historically been.

Shortnose sturgeon spawning occurs near Scudder Falls, well upstream of the any areas where deepening will occur and outside the area where increased salinity is expected. Therefore, selection of spawning sites or the development of eggs and larvae is unlikely to be affected by the deepening. Between now and 2040, due to sea level rise and increases in consumptive water use, there may be a reduction of available habitat for juvenile shortnose sturgeon in some years. However, given the small effect of the deepening on the predicted change in the location of the salt line, effects of the deepening on the distribution of shortnose sturgeon are likely to be insignificant.

7.9.4 Effects of Salinity Change on Sea Turtles

Sea turtles occur in saline sea water. Sea turtles do not occur in the reaches of the river where increases in salinity may be experienced. No impacts to sea turtles from increase in salinity will occur.

7.10 Effects of Deepening on Dissolved Oxygen

Shortnose and Atlantic sturgeon are known to be more sensitive to low dissolved oxygen levels than many other fish species and juvenile sturgeon are particularly sensitive to low dissolved oxygen levels. In comparison to other fishes, sturgeon have a limited behavioral and physiological capacity to respond to hypoxia (multiple references reviewed and cited in Secor and Niklitschek 2001, 2003). Sturgeon basal metabolism, growth, consumption and survival are all very sensitive to changes in oxygen levels, which may indicate their relatively poor ability to oxyregulate. Sturgeon may be negatively affected, primarily through changes in behavior and distribution, when dissolved oxygen levels are below 5mg/l, particularly at times when water temperatures are higher than 28°C (see Flourney *et al.* 1992; Campbell and Goodman 2004).

In certain areas and during certain times of year, dissolved oxygen levels in the Delaware River may be stressful to sturgeon. As sea turtles are air breathers, they are not directly affected by dissolved oxygen levels; however, if dissolved oxygen levels affect sea turtle prey, sea turtles could be affected as well. We have considered whether the deepening project and subsequent maintenance are likely to affect dissolved oxygen levels in the action area. Dissolved oxygen levels could be affected due to increases in suspended sediment and if submerged aquatic

vegetation was affected.

USACE has indicated that there is no SAV in the areas where dredging will occur or where dredged material will be disposed of (i.e., the area at Broadkill Beach). There may be SAV, particularly wild celery, near areas where pipes transporting dredged material will be placed. However, pre-construction surveys will take place to ensure that pipe is laid out in a way that avoids SAV. No SAV will be destroyed or buried due to dredging or dredged material disposal. Further, because there is no SAV where dredging will occur, no SAV will be exposed to turbidity or suspended sediment.

As discussed in Sections 7.1, 7.2, 7.3 and 7.4, there will be small, short term increases in suspended sediment and turbidity near where dredging is occurring and when dredged material is disposed of at Broadkill Beach. However, given the short duration and limited geographic extent of these increases in suspended sediment and turbidity any effects to dissolved oxygen are similarly likely to be limited to small areas and for short periods of time. As such, any effects to sea turtles, shortnose sturgeon or Atlantic sturgeon will be insignificant and discountable.

7.11 Effects to Atlantic sturgeon spawning

Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers, where optimal flows are 46-76 cm/s and depths of 11-27 meters (Borodin 1925, Leland 1968, Scott and Crossman 1973, Crance 1987, Bain *et al.* 2000). Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (e.g., cobble) (Gilbert 1989, Smith and Clugston 1997). Here, we consider effects of the deepening project on factors that are important to Atlantic sturgeon spawning habitat selection.

Spawning is thought to occur at two locations, rkm 170-190 and rkm 120-150 (Breece 2011). The upriver site is outside of the area where deepening will occur. The lower site overlaps with portions of Reach A and Reach B. The timing of dredging and blasting in those reaches has been designed to minimize the potential for disruption of spawning adults or effects to early life stages. All dredging work in these reaches will occur between August and March; spawning occurs in April and May. Blasting and associated cleanup will occur between December 1 and March 15, and we do not expect these activities to reduce the use of this area for Atlantic sturgeon spawning. Tagged adult Atlantic sturgeon have been recorded in the river as late as August causing some to speculate that spawning may occur later in the year than previously thought; however, at this time there is no evidence to indicate that spawning occurs in August or later in the year. Spawning adults are not likely to be present when dredging or blasting occurs; thus, there will be no direct disruption of spawning activity. No eggs will be present during this time of year and all larvae are likely to have developed to a mobile stage which reduces their vulnerability to the proposed action. During the spring of 2016, dredging will be ongoing in Reach E while adults are making upstream movements to the spawning grounds. Due to the localized effects of dredging (sediment disturbance, noise), we do not anticipate that their movements will be disrupted or delayed by the dredging activity. The documented movement of tagged sturgeon through areas where active dredging is occurring (see Section 7.2) supports this determination.

The deepening, including blasting, is expected to result in a minor increase in salinity in some areas of the river. Models indicate that the expected change in salinity is very small. As such, it is not expected that the deepening will affect salinity enough to change the suitability of spawning sites, the selection of spawning locations by adults, or the success of development of any eggs or larvae.

The deepening is expected to have an insignificant effect on water velocity in the river. Models indicate that the expected change in flow near the bottom of the river is less than 1 cm/sec (USACE 1997). As such, it is not expected that the deepening will affect the substrate in a way that will have any effect on the suitability of spawning sites, the selection of spawning locations by adults, or the success of development of any eggs or larvae.

The deepening will increase depths in the dredged areas from 40 to 45 feet. However, because both of these depths are within the range of depths used for sturgeon spawning, it is not expected that the increase in depth will have any effect on the suitability of spawning sites, the selection of spawning locations by adults, or the success of development of any eggs or larvae.

The deepening will remove substrate from the river bottom. However, no changes in substrate type are anticipated and there will be no reduction in hard bottom habitat in the river. Because of that, it is not expected that the deepening will affect the substrate in a way that will have any effect on the suitability of spawning sites, the selection of spawning locations by adults, or the success of development of any eggs or larvae.

Maintenance dredging activity will occur between August and December; thus, the analysis for effects of deepening also applies to maintenance activities. Based on our analysis, we have determined that any effects of the deepening on Atlantic sturgeon spawning will be insignificant and discountable.

7.12 Use of Channel by Vessels

During the consultation process, we requested information from USACE as to whether there would be any expected port expansion resulting from the proposed deepening. USACE indicated that the 45-foot project was formulated, evaluated, and authorized by Congress based on the parameter that no tonnage will be induced or attracted to the port's facilities as a direct result of the proposed deepening of the channel depth for the five-foot increment from 40 to 45 feet. Any future increase in the amount of tonnage through the port over the project life will be an equivalent amount for either the 40 or 45 foot channel depth conditions, and would be predicated on the performance of the U.S. economy. A deeper channel will allow vessels to more efficiently apportion vessel operating costs over the same magnitude of tonnage, resulting in transportation savings. The largest vessels in the fleet, crude oil tankers, will continue to carry the same amount of imported crude to the Big Stone Beach anchorage (located in the naturally deeper water in the lower Delaware Bay). The Coast Guard allowance for sailing drafts of the tankers into the anchorage is 55 feet. Lightering requirements will be reduced for these tankers with the channel deepening, which will lessen the number of barge trips required to carry crude to the refineries upriver. So, overall, the total vessel/barge traffic through the Delaware River port system will be less with the 45 foot deepening as compared to the traffic for the existing 40 foot channel depth.

Overall, future cargo growth is expected to be modest (with flat tonnage factored for crude oil and petroleum products, and only small to moderate growth for dry bulk and container traffic). In summary, the 45 foot channel depth improvement would not necessitate any expansion of the port facilities utilized for tonnage with the current 40 foot channel scenario; therefore, there is not expected to be any increase in risk of vessel strike for any listed species due to the increased depth of the channel.

Two new marine terminals have been proposed since the deepening was initiated (Paulsboro and Southport); however, as explained in the 2011 EA, these terminals are not dependent on the deepening as they do not require depths of 45 feet in order to be used. Therefore, their effects are not effects of this proposed action, the deepening of the Federal Navigation Channel. To date, only the Paulsboro project has been permitted; a separate consultation was completed between USACE and us in 2010 to consider effects of the project on shortnose and Atlantic sturgeon and sea turtles. The wharf will accommodate four berths and is expected to handle a variety of general cargo. Berths 1, 2 and 3 are designed to accommodate Handymax class cargo vessels, which are typically 650 feet long and 95 feet wide. The fourth berth will be designated as a barge berth and is designed to accommodate a typical 400-foot long by 100-foot wide barge. A ship traffic modeling study dated September 2010 was provided to us by USACE during the consultation. The results of the model show the expected increase in the daily number of vessels at seven locations within the Delaware River once the Paulsboro terminal is operational. The increase in daily counts at any location is consistently less than 1 and the 95% confidence interval is between 0.7 and 1. Using this model, USACE predicted that the construction and operation of the Paulsboro Marine Terminal will, on average, result in an increase of one additional ship in the Delaware River per day. In our 2010 consultation, we determined, given the large volume of traffic on the river and the wide variability in traffic in any given day, the increase in traffic of one cargo vessel per day is negligible and that it is unlikely there would be any detectable increase in the risk of vessel strike to shortnose or Atlantic sturgeon or sea turtles.

8.0 CUMULATIVE EFFECTS

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

Actions carried out or regulated by the States of New Jersey, Delaware and Pennsylvania within the action area 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 effects²². The activities discussed in the Cumulative Effects

²² Cumulative effects are defined for NEPA as “the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.”

section of the 2011 EA developed for the deepening project – the Paulsboro Marine Terminal and the Southport Marine Terminal require authorization by the US Army Corps of Engineers, therefore they are considered Federal actions and do not meet the definition of “cumulative effects” under the ESA. USACE has stated that both of these actions involve dredging up to 40 feet, and are not dependent on the deepening project; thus, they cannot be considered interrelated or interdependent actions either.

The Paulsboro Marine Terminal has received a Department of the Army permit for construction. We completed section 7 consultation with USACE to consider the effects of this project on shortnose and Atlantic sturgeon. In a letter dated July 25, 2011, we determined that all effects to these species would be insignificant and discountable. The New Jersey Department of Environmental Protection issued their permit including water quality certification and coastal zone management approval on October 15, 2010. The project is to re-develop the former 130-acre British Petroleum (BP) Oil Terminal and the adjacent 45-acre former Essex Industrial Chemicals, Inc. (Essex) properties located adjacent to the Delaware River and Mantua Creek in the Borough of Paulsboro, Gloucester County into a new, deep-water marine terminal with associated processing, distribution, assembly and intermodal operations. The terminal is expected to be operational in 2016.

The Southport Marine Terminal is still in the planning stages, and is currently undergoing the Department of the Army permit process. The project location is at the eastern end of the Philadelphia Naval Business Center, formerly known as the Philadelphia Naval Shipyard, in the city and county of Philadelphia, Pennsylvania. The proposed project would construct a new marine terminal on approximately 116 acres of currently vacant land. We provided comments to the USACE in response to an August 24, 2010, Public Notice. No section 7 consultation has occurred to date, but we expect that any necessary consultation will occur prior to any USACE approval of the project. 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 over 100 shortnose sturgeon were captured annually in shad fisheries in the Delaware River, with an unknown mortality rate (O'Herron and Able 1985); no recent estimates of captures or mortality are available. Atlantic sturgeon were also likely incidentally captured in shad fisheries in the river; however, estimates of the number of captures or the mortality rate are not available. Recreational shad fishing is currently allowed within the Delaware River with hook and line only; commercial fishing for shad occurs with gill nets, but only in Delaware Bay. In 2012, only one commercial fishing license was granted for shad in New Jersey. Shortnose and Atlantic sturgeon continue to be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to shortnose and Atlantic sturgeon are likely less than they were in the past.

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 Jersey, Delaware and Pennsylvania have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Permittees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the SPDES permits. However, this Opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the status of the species/environmental baseline section.

9.0 INTEGRATION AND SYNTHESIS OF EFFECTS

In the effects analysis outlined above, we considered potential effects from the following sources: (1) deepening of the channel with cutterhead and hopper dredges; (2) blasting at Marcus Hook and associated debris removal with a mechanical dredge including relocation trawling and acoustic deterrence; (3) physical alteration of the action area including effects to benthic communities, substrate type, and in salinity in the action area and (4) maintenance dredging of the deepened channel as scheduled through 2027. In addition to these categories of effects, we considered the potential for collisions between listed species and project vessels, the potential for the deepened channel to result in an increase in vessel traffic in the action area and the potential for effects to Atlantic sturgeon spawning. We anticipate the mortality of a small number of loggerhead and Kemp's ridley sea turtles, shortnose sturgeon, and Atlantic sturgeon from the five DPSs. Mortality of sea turtles will result from entrainment in hopper dredges operating in the Bay. Mortality of Atlantic and shortnose sturgeon will occur from entrainment in hopper and/or cutterhead dredges and capture during mechanical dredging. Injury to a small number of sturgeon may also result from capture during relocation trawling. As explained in the "Effects of the Action" section, effects of the deepening on habitat and benthic resources will be insignificant and discountable. We do not anticipate any take of shortnose or Atlantic sturgeon due to any of the other effects including vessel traffic and dredge disposal.

In the discussion below, we consider whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of the listed species that will be adversely affected by the action. 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 any listed species in the action area. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals

producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter.” Recovery is defined as, “Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act.” Below, for the listed species that may be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the Federal Endangered Species Act.

9.1 Shortnose sturgeon

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

The Delaware River population of shortnose sturgeon is the second 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. The most recent population estimate for the Delaware River is 12, 047 (95% CI= 10,757-13,580) and is based on mark recapture data collected from January 1999 through March 2003 (ERC Inc. 2006). Comparisons between the population estimate by ERC Inc. and the earlier estimate by Hastings *et al.* (1987) of 12,796 (95% CI=10,228-16,367) suggests that the population is stable, but not increasing.

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, adds uncertainty to any determination on the status of this species as a whole. Based on the best available information, we consider the status of shortnose sturgeon throughout their range to be stable.

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Delaware River are affected by impingement at water intakes, habitat alteration, dredging, 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 Delaware River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions we obtain some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Delaware River each year, with little if any mortality. With the exception of the five shortnose sturgeon observed during dredging activities in the 1990s, and the shortnose sturgeon killed during the pilot relocation study, we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. We also have no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Delaware River since the 1970s when the CWA was implemented, with significant improvements below Philadelphia which was previously considered unsuitable for shortnose sturgeon and is now well used. Shortnose sturgeon in the Delaware River have full, unimpeded access to their historic range in the river and appear to be fully utilizing all suitable habitat; this suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Salem nuclear power plant occurs occasionally, with typically less than one mortality per year. In high water years, there is some impingement and entrainment of larvae at facilities with intakes in the upper river; however, documented instances are rare and have involved only small numbers of larvae. Bycatch in the shad fishery, primarily hook and line recreational fishing, historically may have impacted shortnose sturgeon, particularly because it commonly occurred on the spawning grounds. However, little to no mortality was thought to occur and due to decreases in shad fishing, impacts are thought to be less now than they were in the past. Despite these ongoing threats, the Delaware River population of shortnose sturgeon is stable at high numbers. Over the life of the action, shortnose sturgeon in the Delaware 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 Delaware River population. If the salt line shifts further upstream as is predicted in climate change modeling, the range of juvenile shortnose sturgeon is likely to be restricted. However, because there is no barrier to upstream movement it is not clear if this will impact the stability of the Delaware River population of shortnose sturgeon; we do not anticipate changes in distribution or abundance of shortnose sturgeon in the river due to climate change in the time period considered in this Opinion. As such, we expect that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

We have estimated that the ongoing deepening will result in the mortality of: one shortnose sturgeon during the deepening of reach B with a cutterhead dredge, up one shortnose sturgeon during debris removal with a mechanical dredge in reach B (following blasting), and up to 24 mortalities during the maintenance phase (through 2027). We expect that the shortnose sturgeon killed could be juveniles or adults. All other effects to shortnose sturgeon, including effects to habitat and prey due to dredging and dredge disposal, will be insignificant and discountable. We also anticipate the capture of up to 1,061 shortnose sturgeon during relocation trawling and the acoustic tagging and associated minor injury (resulting from tag-related surgery) of up to 130 of those sturgeon. We do not anticipate any injury or death to result from exposure to the detonations during rock blasting in reach B.

Capture during relocation trawling will temporarily disrupt overwintering. However, these behaviors are expected to resume as soon as the fish are returned to the water. Captured sturgeon that are tagged will experience minor injury at the tagging site and may experience short term stress due to handling and surgery. However, recovery is expected to be rapid and occur without any reduction in fitness. The capture, handling, tagging and relocation of live sturgeon is not likely to reduce the numbers of shortnose sturgeon. Similarly, as the capture of live shortnose sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live sturgeon is also not likely to affect the distribution of shortnose sturgeon throughout their range. As any effects to individual shortnose sturgeon captured during relocation trawling and temporarily removed from the water will be minor and temporary, there are not anticipated to be any population level impacts.

The number of shortnose sturgeon that are likely to die as a result of the ongoing deepening project and maintenance through 2027 (26), represents an extremely small percentage of the shortnose sturgeon population in the Delaware 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 12,047 shortnose sturgeon in the Delaware River (ERC 2006). While the death of up to 26 shortnose sturgeon between now and 2027 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 (approximately 0.22%). The effect of this loss is also lessened as it will be experienced slowly over time, with the death of an average of two shortnose sturgeon per year.

Reproductive potential of the Delaware 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 Delaware 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 1/2 of males spawn in a particular year. Given that the best available estimates indicate that there are more than 12,000 shortnose sturgeon in the Delaware River, it is reasonable to expect that there are at least 5,000 adults spawning in a particular year. It is unlikely that the loss of 26 shortnose sturgeon over a 12-year period at a rate of approximately two per year 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 while the action will temporarily

affect the distribution of individual sturgeon by displacing sturgeon captured with the trawl from one area and relocating them to alternate overwintering area and sturgeon may temporarily avoid areas where dredging, blasting or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. 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 approximately 0.22% of the Delaware 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 26 shortnose sturgeon over a 12-year period resulting from the ongoing deepening of the Delaware River and maintenance through 2027, 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 (*i.e.*, it will not increase the risk of extinction faced by this species). This is the case because: given that: (1) the population trend of shortnose sturgeon in the Delaware River is stable; (2) the death of up to 26 shortnose sturgeon represents an extremely small percentage of the number of shortnose sturgeon in the Delaware 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 Delaware 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 Delaware 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 around the working dredge) 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 rare instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the

likelihood that shortnose 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 under ESA Section 4(a) as “in danger of extinction throughout all or a significant portion of its range” (endangered) or “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range...” (threatened) is no longer warranted. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where shortnose sturgeon are no longer in danger of extinction through all or a significant part of their range.

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

The Delaware River population of shortnose sturgeon is stable at high numbers. This action will not change the status or trend of the Delaware River population of shortnose sturgeon or the species as a whole. This is because the reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river’s carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where deepening and maintenance dredging and blasting will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be minor. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area.

The proposed action will not affect shortnose sturgeon outside of the Delaware River. Because it will not reduce the likelihood that the Delaware River population can recover, it will not reduce the likelihood that the species as a whole can recover. Therefore, the proposed action will not

appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.2 Atlantic sturgeon

As explained above, the remaining deepening and maintenance dredging scheduled through 2027 is likely to result in the death of up to 26 juvenile and/or subadult Atlantic sturgeon (one during deepening of reach B with a cutterhead; one during removal of rock debris with a mechanical dredge following blasting in reach B; and up to 24 during maintenance dredging of the deepened channel. We expect that the Atlantic sturgeon killed will be YOY, juvenile subadults. We do not anticipate the mortality of any adults. All other effects to Atlantic sturgeon, including effects to habitat and prey due to dredging and dredge disposal, will be insignificant and discountable. We also anticipate the capture of up to 571 Atlantic sturgeon during relocation trawling and the tagging and minor injury (resulting from tag-related surgery) to 70 of those. We expect all of the Atlantic sturgeon captured during relocation trawling to originate from the NYB DPS because tracking studies indicate that subadult and adult Atlantic sturgeon are not present in the Marcus Hook area during the winter. Juvenile Atlantic sturgeon from other DPSs remain in their natal river and would not occur in Marcus Hook.

9.2.1 Determination of DPS Composition

We have considered the best available information to determine from which DPSs individuals that will be killed are likely to have originated. Using mixed stock analysis explained above, with the exception of relocation trawling, blasting and mechanical dredging, which will impact only Atlantic sturgeon from the NYB DPS (due to location and time of year), Atlantic sturgeon exposed to other effects of the proposed action originate from the five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. Given these percentages, we expect that of the 26 sturgeon likely to be killed during dredging, 15 will originate from the New York Bight DPS, 5 from the Chesapeake Bay DPS, 4 from the South Atlantic DPS, and 2 from the Gulf of Maine DPS. Given the low numbers of Carolina DPS fish in the action area and the low number of mortalities anticipated, it is unlikely that there will be any mortality of any Carolina DPS Atlantic sturgeon.

9.2.2 Gulf of Maine DPS

While GOM DPS Atlantic sturgeon occur in several rivers in the Gulf of Maine, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 7,544 GOM DPS adults and subadults in the ocean (1,864 adults and 5,591 subadults). This estimate is the best available at this time and represents only a percentage of the total GOM DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. 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.

Based on mixed-stock analysis, we expect that 7% of the subadult and adult Atlantic sturgeon in the action area will originate from the GOM DPS. While some adults from the GOM DPS are expected to be present in the Delaware River, no mortality of adult Atlantic sturgeon is anticipated to result from the proposed action. We expect that no more than two GOM DPS Atlantic sturgeon will be killed during dredging. This mortality will occur between now and the end of 2027.

The number of subadult GOM DPS Atlantic sturgeon we expect to be killed due to the ongoing project (two between now and the end of 2027) represents an extremely small percentage of the GOM DPS. While the death of two subadult GOM DPS Atlantic sturgeon over this period 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 GOM DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if there were only 5,591 subadults in the GOM DPS, this loss would represent only 0.04% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of two female subadults 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. The loss of two male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning. The proposed action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how GOM DPS sturgeon use the action area.

Based on the information provided above, the death of no more than two subadult GOM DPS Atlantic sturgeon over 12 years, 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 or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of two subadult GOM DPS Atlantic sturgeon represents an extremely small percentage of the population of the DPS; (2) the death of two GOM DPS Atlantic sturgeon will not change the status or trends of the DPS as a whole; (3) the loss of two GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of two subadult GOM 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 DPS; (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 DPS throughout its range; and, (6) the action will have only an insignificant effect on individual foraging, migrating, or sheltering GOM DPS Atlantic sturgeon.

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

A Recovery Plan for the GOM DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for GOM Atlantic sturgeon, individuals must have access to enough habitat in suitable condition for foraging, migrating, resting, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the GOM DPS likelihood of recovery.

This action will not change the status or trend of the GOM DPS as a whole. The proposed action will result in a small amount of mortality (two subadults from a population estimated to have at

least 5,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where deepening, blasting, and maintenance dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be minor. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area.

The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the GOM DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.3 New York Bight DPS

The NYB DPS is listed as endangered. All early life stages (eggs and larvae), young of the year and juvenile Atlantic sturgeon in the action area originate from the Delaware River and belong to the NYB DPS. Based on Mixed Stock Analysis, we expect that 58% of the subadult and adult Atlantic sturgeon in the action area will originate from the NYB DPS. No mortality of adult Atlantic sturgeon is anticipated. To date, three Atlantic sturgeon, assumed to be from the NYB DPS, have been entrained during the deepening and associated maintenance to date; two of these were released from the dredge alive and one was dead. Over the course of the remaining deepening and maintenance dredging (through 2027), we anticipate the mortality of up to 15 NYB DPS Atlantic sturgeon. These sturgeon could be killed due to entrainment in a hopper or cutterhead dredge, or capture in a mechanical dredge. These fish could be Delaware River origin juveniles or subadult originating from the Delaware or Hudson River. While it is possible that entrained fish could survive, we assume here that these fish will be killed.

We anticipate the capture of up to 571 NYB DPS Atlantic sturgeon during relocation trawling to be carried out in during the two blasting seasons (December 2015-March 2016; December 2016-March 2017). Capture during relocation trawling and acoustic deterrence will temporarily disrupt overwintering. However, these behaviors are expected to resume as soon as the fish are returned to the water upriver. Captured sturgeon that are tagged (up to 70) will experience minor injury at the tagging site and may experience short term stress due to handling and surgery. However, recovery is expected to be rapid and occur without any reduction in fitness. The capture, handling, tagging, and relocation of live sturgeon are not likely to reduce the numbers of NYB DPS Atlantic sturgeon. Similarly, as the capture of live sturgeon will not affect the fitness of any individual, no effects to reproduction are anticipated. The capture of live sturgeon is also not

likely to affect the distribution of NYB DPS Atlantic sturgeon throughout their range. As any effects to individual sturgeon captured during relocation trawling and temporarily removed from the water will be minor and temporary there are not anticipated to be any population level impacts.

While NYB DPS Atlantic sturgeon occur in several rivers in the NYB DPS, spawning has until recently only been documented in the Hudson and Delaware rivers. The capture of age-0 Atlantic sturgeon in the Connecticut River indicates that spawning, at least in some years, is likely occurring in that river as well. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated there to be 34,566 NYB DPS adults and subadults in the ocean (8,642 adults and 25,925 subadults). This estimate is the best available at this time and represents only a percentage of the total NYB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. NYB 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 or for the DPS as a whole.

We have limited information from which to determine the percentage of NYB DPS fish in the Delaware River that are likely to originate from the Delaware vs. the Hudson River (and no information as to the number of DPS origin fish potentially originating from the Connecticut River since evidence of spawning has only recently been documented). Of the 11 fish captured in the Delaware River for which genetic assignments are available, six were from the New York Bight DPS, with four originating from the Delaware River and two from the Hudson River. This suggest that within the Delaware River, the composition of New York Bight fish is approximately 2/3 Delaware and 1/3 Hudson.

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

The mortality of up to 15 juvenile or subadult Atlantic sturgeon from the NYB DPS over a 12-year period represents a very small percentage of the subadult and juvenile population. While the death of one juvenile or subadult Atlantic sturgeon will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the juvenile and subadult population and an even smaller

percentage of the overall population of the DPS (juveniles, subadults and adults combined).

The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of 15 female juvenile or subadults over a 12 year period (average of just over one per year) would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of 15 male juvenile or subadult sturgeon may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that for any sturgeon that are not killed, any impacts to behavior will be minor and temporary and there will not be any delay or disruption of movements to the spawning grounds or to actual spawning. Further, we have determined that any impacts to spawning and rearing habitat will be minor and temporary.

The proposed action will also not affect the spawning grounds within the Hudson River where most NYB DPS fish spawn nor will it affect any spawning grounds that exist on the Connecticut River. Additionally, we have considered effects of the proposed action on habitat used for spawning in the Delaware River and have determined that all effects will be insignificant and discountable. The action will also not prevent or delay any adult Atlantic sturgeon from reaching the spawning grounds. Further, we do not anticipate the disruption, injury or mortality of any spawning adults.

The proposed action is not likely to reduce distribution because while the action will temporarily affect the distribution of individual sturgeon by displacing sturgeon captured with the trawl from one area and relocating them to alternate overwintering area and sturgeon may temporarily avoid areas where dredging, blasting or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon.

Based on the information provided above, the death of 15 NYB DPS Atlantic sturgeon over a 12-year period, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these juveniles or subadults NYB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these NYB DPS Atlantic sturgeon

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

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

A Recovery Plan for the NYB DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting, migrating, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson or Delaware River populations of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will result in a small amount of mortality (no more than 15 individuals over a 12 year period) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the

population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where blasting, deepening, and maintenance dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be minor. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. Because it will not reduce the likelihood that the Hudson or Delaware River population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.4 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. We expect that 18% of the subadult and adult Atlantic sturgeon in the action area will originate from the CB DPS. Most of these fish are expected to be subadults, with few adults from the CB DPS expected to be present in the Delaware River. No mortality of adult Atlantic sturgeon is anticipated. We expect that no more than 26 Atlantic sturgeon will be killed during the remaining deepening and associated maintenance dredging (through 2027) and that no more than 5 of these will originate from the CB DPS. These fish are likely to be subadults as juvenile CB DPS fish would not be present in the Delaware River. While it is possible that entrained fish could survive, we assume here that the fish will be killed.

While CB DPS Atlantic sturgeon occur in several rivers, recent spawning has only been documented in the James River and York River systems. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 8,811 CB DPS adults and subadults in the ocean (2,203 adults and 6,608 subadults). This estimate is the best available at this time and represents only a percentage of the total CB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. CB 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 or for the DPS as a whole.

The number of subadult CB DPS Atlantic sturgeon we expect to be killed due to the ongoing deepening and maintenance (5 over a 12-year period) represents an extremely small percentage of the CB DPS. While the death of 5 subadult CB DPS Atlantic sturgeon over the next 12 years 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 CB DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if

there were only 6,608 subadults in the CB DPS, this loss would represent only 0.08% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the CB DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of 5 female subadults 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. The loss of male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that for any sturgeon that are not killed, any impacts to behavior will be minor and temporary and there will not be any delay or disruption of movements to the spawning grounds or actual spawning. Further, the proposed action will also not affect the spawning grounds within the rivers where CB DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how CB DPS sturgeon use the action area.

Based on the information provided above, the death of no more than 5 subadult CB DPS Atlantic sturgeon over 12 years, 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 or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these subadult CB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult CB 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 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 only an insignificant effect on individual foraging, migrating, or sheltering CB DPS Atlantic sturgeon.

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

A Recovery Plan for the CB DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, migrating, resting, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the CB DPS likelihood of recovery.

This action will not change the status or trend of the CB DPS as a whole. The proposed action will result in a small amount of mortality (five subadults from a population estimated to have at least 6,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where deepening and maintenance dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be minor. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the CB DPS can recover. Therefore, the proposed

action will not appreciably reduce the likelihood that the CB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.5 South Atlantic DPS

Individuals originating from the SA DPS are likely to occur in the action area. The SA DPS has been listed as endangered. We expect that 17% of the subadult and adult Atlantic sturgeon in the action area will originate from the SA DPS. Most of these fish are expected to be subadults, with few adults from the SA DPS expected to be present in the Delaware River. No mortality of adult Atlantic sturgeon is anticipated. We expect that no more than 26 Atlantic sturgeon will be killed during deepening or subsequent maintenance dredging and that no more than 4 of these will originate from the SA DPS. These fish are likely to be a subadult as juvenile SA DPS fish would not be present in the Delaware River. While it is possible that the entrained fish could survive, we assume here that the fish will be killed.

No total population estimates are available for any river population or the SA DPS as a whole. As discussed in section 4.7, we have estimated a total of 14,911 SA DPS adults and subadults in the ocean (3,728 adults and 11,183 subadults). This estimate is the best available at this time and represents only a percentage of the total SA DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. SA 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 or for the DPS as a whole.

The number of subadult SA DPS Atlantic sturgeon we expect to be killed due to the ongoing deepening and maintenance of the Philadelphia to the Sea channel (4 over a 12-year period) represents an extremely small percentage of the SA DPS. While the death of 4 subadult SA DPS Atlantic sturgeon over the next 12 years will reduce the number of SA 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 SA DPS population of subadults and an even smaller percentage of the DPS as a whole. Even if there were only 11,183 subadults in the SA DPS, this loss would represent less than 0.04% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the SA DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of up to four female subadults would have the effect of reducing the amount of potential reproduction as any dead SA DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be

killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that for any sturgeon that are not killed, any impacts to behavior will be minor and temporary and there will not be any delay or disruption of movements to the spawning grounds or to actual spawning. Further, the proposed action will also not affect the spawning grounds within the rivers where SA DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how SA DPS sturgeon use the action area.

Based on the information provided above, the death of no more than 4 subadult SA DPS Atlantic sturgeon over 12 years, will not appreciably reduce the likelihood of survival of the SA 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 SA DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these subadult SA DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these SA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these SA DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult SA 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 SA 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 only an insignificant effect on individual foraging or sheltering SA DPS Atlantic sturgeon.

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

likelihood that SA DPS of Atlantic sturgeon can rebuild to a point where it is no longer in danger of extinction through all or a significant part of its range.

A Recovery Plan for the SA DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the SA DPS likelihood of recovery.

This action will not change the status or trend of the SA DPS as a whole. The proposed action will result in a small amount of mortality (4 subadults from a population estimated to have at least 11,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where deepening and maintenance dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be minor. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. The proposed action will not affect SA DPS of Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the SA DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.2.6 Carolina DPS

As explained in section 4.7, no Carolina DPS fish have been documented in the action area. This is based on genetic sampling of fish in the Delaware River (n=11 individuals) and sampling in Delaware coastal waters (n=105). However, Carolina DPS fish have been documented in Long Island Sound (0.5% of samples). Because Carolina fish would swim past Delaware Bay on their

way to Long Island Sound, we considered the possibility that up to 0.5% of the Atlantic sturgeon in the action area would originate from the Carolina DPS. However, given the low level of lethal take anticipated (up to 26 over a 12 year period) and the expected rarity of Carolina fish in the action area, it is extremely unlikely that any of the fish that will be killed during the deepening or subsequent maintenance will originate from the Carolina DPS. We do not expect any Carolina DPS fish to be present in the action area during the winter months when blasting or when the relocation trawl project will be carried out; therefore, no Carolina DPS fish will be exposed to any effects of those activities. All other effects to Atlantic sturgeon, including habitat and prey, will be insignificant and discountable. Therefore, the action considered in this Opinion is not likely to adversely affect the Carolina DPS of Atlantic sturgeon.

9.3 Green sea turtles

As noted in sections above, the physical disturbance of sediments and entrainment of associated benthic resources could reduce the availability of sea turtle prey in the affected areas, but these reductions will be localized and temporary, and foraging turtles are not likely to be limited by the reductions and any effects will be insignificant. Also, as explained above, no green sea turtles are likely to be entrained in any dredge operating to deepen or maintain the channel and this species is not likely to be involved in any collision with a project vessel. As all effects to green sea turtles from the proposed project are likely to be insignificant or discountable, this action is not likely to adversely affect this species.

9.4 Leatherback sea turtles

As noted in sections above, the physical disturbance of sediments and entrainment of associated benthic resources could reduce the availability of sea turtle prey in the affected areas, but these reductions will be localized and temporary, and foraging turtles are not likely to be limited by the reductions and any effects will be insignificant. Also, as explained above, no leatherback sea turtles are likely to be entrained in any dredge operating to deepen or maintain the channel and this species is not likely to be involved in any collision with a project vessel. As all effects to leatherback sea turtles from the proposed project are likely to be insignificant or discountable, this action is not likely to adversely affect this species.

9.5 Kemp's ridley sea turtles

In the "Effects of the Action" section above, we determined that Kemp's ridleys could be entrained in a hopper dredge working to deepen Reach D or E or by a hopper dredge conducting maintenance dredging activities in either of these reaches. No interactions with Kemp's ridleys have been recorded in the deepening and maintenance dredging that has occurred to date. Based on a calculated entrainment rate of sea turtles for projects using hopper dredges in the action area, we estimate that 1 sea turtle is likely to be entrained for every 600,000 cy of material removed with a hopper dredge. Also, based on the ratio of loggerhead and Kemp's ridleys entrained in other hopper dredge operations in the USACE North Atlantic Division, we estimate that no more than 10% of the sea turtles entrained during project operations were likely to be Kemp's ridleys with the remainder loggerheads. Based on this, we determined that of the 13 sea turtles likely to be entrained during the remainder of the deepening and subsequent maintenance dredging, no more than two are likely to be a Kemp's ridley (one resulting from deepening, one resulting from maintenance dredging); the remainder will likely be loggerheads.

Kemp's Ridley sea turtles are listed as a single species classified as "endangered" under the ESA. Kemp's ridleys occur in the Atlantic Ocean and Gulf of Mexico. The only major nesting site for Kemp's ridleys is a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; USFWS and NMFS 1992; NMFS and USFWS 2007c).

Nest count data provide the best available information on the number of adult females nesting each year. As is the case with the other sea turtle species discussed above, nest count data must be interpreted with caution given that these estimates provide a minimum count of the number of nesting Kemp's ridley sea turtles. In addition, the estimates do not account for adult males or juveniles of either sex. Without information on the proportion of adult males to females, and the age structure of the Kemp's ridley population, nest counts cannot be used to estimate the total population size (Meylan 1982; Ross 1996; Zurita *et al.* 2003; Hawkes *et al.* 2005; letter to J. Lecky, NMFS Office of Protected Resources, from N. Thompson, NMFS Northeast Fisheries Science Center, December 4, 2007). Nevertheless, the nesting data do provide valuable information on the extent of Kemp's ridley nesting and the trend in the number of nests laid. Estimates of the adult female nesting population reached a low of approximately 250-300 in 1985 (USFWS and NMFS 1992; TEWG 2000). From 1985 to 1999, the number of nests observed at Rancho Nuevo and nearby beaches increased at a mean rate of 11.3% per year (TEWG 2000). Current estimates suggest an adult female population of 7,000-8,000 Kemp's ridleys (NMFS and USFWS 2007c).

The most recent review of the Kemp's ridleys suggests that this species is in the early stages of recovery (NMFS and USFWS 2007b). Nest count data indicate increased nesting and increased numbers of nesting females in the population. We also take into account a number of recent conservation actions including the protection of females, nests, and hatchlings on nesting beaches since the 1960s and the enhancement of survival in marine habitats through the implementation of TEDs in the early 1990s and a decrease in the amount of shrimping off the coast of Tamaulipas and in the Gulf of Mexico in general (NMFS and USFWS 2007b). We consider that the status of Kemp's ridleys over the project period will be no worse than it is currently and that the species may actually be in the early stages of recovery, although this should be viewed in the context of a much larger population in the mid-20th century.

The mortality of two Kemp's ridleys over a 12 year time period represents a very small percentage of the Kemp's ridleys worldwide. Even taking into account just nesting females, the death of two Kemp's ridley represents less than 0.03% of the population. While the death of two Kemp's ridley will reduce the number of Kemp's ridleys 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 or its trend as this loss represents a very small percentage of the population (less than 0.03%). Reproductive potential of Kemp's ridleys 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 Kemp's ridleys would have the effect of reducing the amount of potential reproduction as any dead Kemp's ridleys would have no potential for future reproduction. In 2006, the most recent year for which data is available, there were an estimated 7-8,000 nesting females. While the species is thought to be female biased, there are likely to be several thousand

adult males as well. Given the number of nesting adults, it is unlikely that the loss of 2 Kemp's ridleys would affect the success of nesting in any year. Additionally, this small reduction in potential nesters is expected to result in a small reduction in the number of eggs laid or hatchlings produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future nesters 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 to increasing trend of this species. Additionally, the proposed action will not affect nesting beaches in any way or disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting.

The proposed action is not likely to reduce distribution because the action will not impede Kemp's ridleys from accessing foraging grounds or cause more than a temporary disruption to other migratory behaviors. Additionally, given the small percentage of the species that will be killed as a result of the deepening and maintenance, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction 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 Kemp's ridleys because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of Kemp's ridleys is likely to be increasing and at worst is stable.

Based on the information provided above, the death of two Kemp's ridley sea turtles between now and 2027 will not appreciably reduce the likelihood of survival (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 Kemp's ridleys 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 Kemp's ridleys from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of two Kemp's ridleys represents an extremely small percentage of the species as a whole; (2) the death of two Kemp's ridleys will not change the status or trends of the species as a whole; (3) the loss of these Kemp's ridleys is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these Kemp's ridleys 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 Kemp's ridleys 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 Kemp's ridleys to shelter and only an insignificant effect on individual foraging Kemp's ridleys.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but 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 actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that Kemp's ridleys can rebuild to a point where listing is no longer appropriate. In 2011, we issued a recovery plan for Kemp's ridleys (NMFS and USFWS 2011). The plan includes a list of criteria necessary for recovery. These include:

1. An increase in the population size, specifically in relation to nesting females²³;
2. An increase in the recruitment of hatchlings²⁴;
3. An increase in the number of nests at the nesting beaches;
4. Preservation and maintenance of nesting beaches (i.e. Rancho Nuevo, Tepehuajes, and Playa Dos); and,
5. Maintenance of sufficient foraging, migratory, and inter-nesting habitat.

Given the extremely small reduction in numbers, the loss of two Kemp's ridley during the proposed actions (12 years) will not affect the population trend. The number of Kemp's ridleys likely to die as a result of the proposed action is an extremely small percentage of the species. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that criteria one, two or three will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; therefore, the proposed actions will have no effect on the likelihood that recovery criteria four will be met. All effects to habitat will be insignificant and discountable; therefore, the proposed actions will have no effect on the likelihood that criteria five will be met.

The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction. Further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of Kemp's ridleys and a small reduction in the amount of potential reproduction (2 individuals over 12 years), these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

²³ A population of at least 10,000 nesting females in a season (as measured by clutch frequency per female per season) distributed at the primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos) is attained in order for downlisting to occur; an average of 40,000 nesting females per season over a 6-year period by 2024 for delisting to occur

²⁴ Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos).

Despite the threats faced by individual Kemp's ridley sea turtles inside and outside of the actions area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light of cumulative effects explained above and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to two Kemp's ridley sea turtles between now and 2027, is not likely to appreciably reduce the survival and recovery of this species.

9.6 Northwest Atlantic DPS of Loggerhead sea turtles

In the "Effects of the Action" section above, we determined that loggerheads could be entrained in a hopper dredge working to deepen Reach D or E or in a hopper dredge conducting maintenance dredging activities in either of these reaches. No interactions with loggerhead sea turtles have been observed during deepening or maintenance dredging of the deepened channel to date. Based on a calculated entrainment rate of sea turtles for projects using hopper dredges in the action area, we estimate that one sea turtle is likely to be entrained for every 600,000 cy of material removed with a hopper dredge. Also, based on the ratio of loggerhead and Kemp's ridleys entrained in other hopper dredge operations in the USACE North Atlantic Division, we estimate that 90% of the sea turtles entrained during project operations were likely to be loggerheads. Based on this, we determined that of the 13 sea turtles likely to be entrained during the remaining deepening and subsequent maintenance dredging (through 2027), 11 are likely to be loggerheads. All entrained loggerheads are expected to be juveniles. We determined that all other effects of the action on this species will be insignificant and discountable.

The Northwest Atlantic DPS of loggerhead sea turtles is listed as "threatened" under the ESA. It takes decades for loggerhead sea turtles to reach maturity. Once they have reached maturity, females typically lay multiple clutches of eggs within a season, but do not typically lay eggs every season (NMFS and USFWS 2008). There are many natural and anthropogenic factors affecting the survival of loggerheads prior to their reaching maturity as well as for those adults who have reached maturity. As described in the Status of the Species, Environmental Baseline and Cumulative Effects sections above, loggerhead sea turtles in the action area continue to be affected by multiple anthropogenic impacts including bycatch in commercial and recreational fisheries, habitat alteration, dredging, power plant intakes and other factors that result in mortality of individuals at all life stages. Negative impacts causing death of various age classes occur both on land and in the water. Many actions have been taken to address known negative impacts to loggerhead sea turtles. However, many remain unaddressed, have not been sufficiently addressed, or have been addressed in some manner but whose success cannot be quantified.

The SEFSC (2009) estimated the number of adult females in the NWA DPS at 30,000, and if a 1:1 adult sex ratio is assumed, the result is 60,000 adults in this DPS. Based on the reviews of nesting data, as well as information on population abundance and trends, NMFS and USFWS determined in the September 2011 listing rule that the NWA DPS should be listed as threatened.

They found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats. This stable trend is expected to continue over the time period considered in this Opinion.

As stated above, we expect the lethal entrainment of 11 loggerheads over the 12 year time period considered here; with an average mortality rate of almost one loggerhead per year. The lethal removal of up to 11 loggerhead sea turtles from the action area over this time period would be expected to reduce the number of loggerhead sea turtles from the recovery unit of which they originated as compared to the number of loggerheads that would have been present in the absence of the proposed actions (assuming all other variables remained the same). However, this does not necessarily mean that these recovery units will experience reductions in reproduction, numbers or distribution in response to these effects to the extent that survival and recovery would be appreciably reduced. The final revised recovery plan for loggerheads compiled the most recent information on mean number of loggerhead nests and the approximated counts of nesting females per year for four of the five identified recovery units (i.e., nesting groups). They are: (1) for the NRU, a mean of 5,215 loggerhead nests per year with approximately 1,272 females nesting per year; (2) for the PFRU, a mean of 64,513 nests per year with approximately 15,735 females nesting per year; (3) for the DTRU, a mean of 246 nests per year with approximately 60 females nesting per year; and (4) for the NGMRU, a mean of 906 nests per year with approximately 221 females nesting per year. For the GCRU, the only estimate available for the number of loggerhead nests per year is from Quintana Roo, Yucatán, Mexico, where a range of 903-2,331 nests per year was estimated from 1987-2001 (NMFS and USFWS 2007a). There are no annual nest estimates available for the Yucatán since 2001 or for any other regions in the GCRU, nor are there any estimates of the number of nesting females per year for any nesting assemblage in this recovery unit.

It is likely that the loggerhead sea turtles in Delaware Bay originate from several of the recovery units. Limited information is available on the genetic makeup of sea turtles in the mid-Atlantic, where the majority of sea turtle interactions are expected to occur. Cohorts from each of the five western Atlantic subpopulations are expected to occur in the action area. Genetic analysis of samples collected from immature loggerhead sea turtles captured in pound nets in the Pamlico-Albemarle Estuarine Complex in North Carolina from September-December of 1995-1997 indicated that cohorts from all five western Atlantic subpopulations were present (Bass *et al.* 2004). In a separate study, genetic analysis of samples collected from loggerhead sea turtles from Massachusetts to Florida found that all five western Atlantic loggerhead subpopulations were represented (Bowen *et al.* 2004). Bass *et al.* (2004) found that 80 percent of the juveniles and sub-adults utilizing the foraging habitat originated from the south Florida nesting population, 12 percent from the northern subpopulation, 6% from the Yucatan subpopulation, and 2% from other rookeries. The previously defined loggerhead subpopulations do not share the exact delineations of the recovery units identified in the 2008 recovery plan. However, the PFRU encompasses both the south Florida and Florida panhandle subpopulations, the NRU is roughly equivalent to the northern nesting group, the Dry Tortugas subpopulation is equivalent to the DTRU, and the Yucatan subpopulation is included in the GCRU.

Based on the genetic analysis presented in Bass *et al.* (2004) and the small number of loggerheads from the DTRU or the NGMRU likely to occur in the action area it is extremely unlikely that the loggerheads likely to be killed during the deepening project will originate from either of these recovery units. The majority, at least 80% of the loggerheads killed, are likely to have originated from the PFRU, with the remainder from the NRU and GCRU. As such, of the 11 loggerheads likely to be killed, nine are expected to be from the PFRU, with one from the NRU and one from the GCRU. Below, we consider the effects of these mortalities on these three recovery units and the species as a whole.

As noted above, the most recent population estimates indicate that there are approximately 15,735 females nesting annually in the PFRU and approximately 1,272 females nesting per year in the NRU. For the GCRU, the only estimate available for the number of loggerhead nests per year is from Quintana Roo, Yucatán, Mexico, where a range of 903-2,331 nests per year was estimated from 1987-2001 (NMFS and USFWS 2007a). There are no annual nest estimates available for the Yucatán since 2001 or for any other regions in the GCRU, nor are there any estimates of the number of nesting females per year for any nesting assemblage in this recovery unit; however, the 2008 recovery plan indicates that the Yucatan nesting aggregation has at least 1,000 nesting females annually. As the numbers outlined here are only for nesting females, the total number of loggerhead sea turtles in each recovery unit is likely significantly higher.

The loss of nine loggerheads over a 14-year period represents an extremely small percentage of the number of sea turtles in the PFRU. Even if the total population was limited to 15,735 loggerheads, the loss of nine individuals would represent approximately 0.06% of the population. Similarly, the loss of one loggerhead from the NRU represents an extremely small percentage of the recovery unit. Even if the total population was limited to 1,272 sea turtles, the loss of one individual would represent approximately 0.08% of the population. The loss of one loggerhead from the GCRU, which is expected to support at least 1,000 nesting females, represents less than 0.1% of the population. The loss of such a small percentage of the individuals from any of these recovery units represents an even smaller percentage of the species as a whole. The impact of these losses is even less when considering that these losses will occur over a span of 12 years. Considering the extremely small percentage of the populations that will be killed, it is unlikely that these deaths will have a detectable effect on the numbers and population trends of loggerheads in these recovery units or the number of loggerheads in the population as a whole.

All of the loggerheads that are expected to be killed will be juveniles. Thus, any effects on reproduction are limited to the loss of these individuals on their year class and the loss of future reproductive potential. Given the number of nesting adults in each of these populations, it is unlikely that the expected loss of loggerheads would affect the success of nesting in any year. Additionally, this small reduction in potential nesters is expected to result in a small reduction in the number of eggs laid or hatchlings produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future nesters 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 species. Additionally, the proposed action will not affect nesting beaches in any way or

disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting.

The proposed action is not likely to reduce distribution because the action will not impede loggerheads from accessing foraging grounds or cause more than a temporary disruption to other migratory behaviors. Additionally, given the small percentage of the species that will be killed as a result of the deepening and maintenance, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction 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 loggerheads because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of loggerheads is likely to be stable or increasing over the time period considered here.

Based on the information provided above, the death of up to 11 loggerheads between now and 2027 will not appreciably reduce the likelihood of survival (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 loggerheads 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 loggerheads from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the species' nesting trend is stabilizing; (2) the death of 11 loggerheads represents an extremely small percentage of the species as a whole; (3) the death of 11 loggerheads will not change the status or trends of the species as a whole; (4) the loss of these loggerheads is not likely to have an effect on the levels of genetic heterogeneity in the population; (5) the loss of these loggerheads is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (6) the action will have only a minor and temporary effect on the distribution of loggerheads in the action area and no effect on the distribution of the species throughout its range; and, (7) the action will have no effect on the ability of loggerheads to shelter and only an insignificant effect on individual foraging loggerheads.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but 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 actions will not appreciably reduce the likelihood that loggerhead sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the NWA DPS of loggerheads can rebuild to a point where listing is no longer appropriate. In 2008, we issued a recovery plan for

the Northwest Atlantic population of loggerheads (NMFS and USFWS 2008). The plan includes demographic recovery criteria as well as a list of tasks that must be accomplished. Demographic recovery criteria are included for each of the five recovery units. These criteria focus on sustained increases in the number of nests laid and the number of nesting females in each recovery unit, an increase in abundance on foraging grounds, and ensuring that trends in neritic strandings are not increasing at a rate greater than trends in in-water abundance. The recovery tasks focus on protecting habitats, minimizing and managing predation and disease, and minimizing anthropogenic mortalities.

Loggerheads have an increasing trend; as explained above, the loss of 11 loggerheads over 12-years as a result of the proposed actions will not affect the population trend. The number of loggerheads likely to die as a result of the proposed actions is an extremely small percentage of any recovery unit or the DPS as a whole. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that the demographic criteria will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; all effects to habitat will be insignificant and discountable; therefore, the proposed actions will have no effect on the likelihood that habitat based recovery criteria will be achieved. The proposed actions will also not affect the ability of any of the recovery tasks to be accomplished.

In summary, the effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of loggerheads and a small reduction in the amount of potential reproduction due to the loss of these individuals, these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that loggerhead sea turtles can be brought to the point at which they are no longer listed as threatened.

Despite the threats faced by individual loggerhead sea turtles inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light of other threats, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of the NWA DPS of loggerhead sea turtles.

10.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under our jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is our biological opinion that the proposed action may adversely

affect but is not likely to jeopardize the continued existence of the shortnose sturgeon, the GOM, NYB, CB, and SA DPSs of Atlantic sturgeon, Kemp's ridley and loggerhead sea turtles and is not likely to adversely affect Atlantic sturgeon from the Carolina DPS, green, or leatherback sea turtles. Because no critical habitat is designated in the action area, none will be affected by the proposed action.

11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. §1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. § 1538(g). 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 the purpose 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 measures described below are non-discretionary, and must be undertaken by USACE so that they become binding conditions for the exemption in section 7(o)(2) to apply. USACE has a continuing duty to regulate the activity covered by this Incidental Take Statement. If USACE (1) fails to assume and implement the terms and conditions or (2) fails to require any contractors to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added contracts or other documents as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, USACE must report the progress of the action and its impact on the species to us 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).

11.1 Amount or Extent of Incidental Take

The proposed action has the potential to result in the mortality of loggerhead and Kemp's ridley sea turtles, shortnose sturgeon, and individuals from the New York Bight, Gulf of Maine, Chesapeake Bay and South Atlantic DPSs of Atlantic sturgeon due to entrainment in hopper or

cutterhead dredges. Shortnose sturgeon and individuals from the New York Bight DPSs of Atlantic sturgeon are likely to be captured and killed in the dredge bucket during debris removal after blasting. Entrainment of sea turtles is only likely to occur in hopper dredges working in Reach D and Reach E. Entrainment of shortnose and Atlantic sturgeon is likely to occur in hopper and cutterhead dredges operating in Reaches AA, A, B and C. Take may occur during the initial construction period as well as during maintenance dredging planned through 2027. Additionally, the relocation trawling is expected to result in the capture and minor injury of up to 1,632 shortnose and NYB DPS Atlantic sturgeon. Up to 200 of these sturgeon will experience minor injury resulting from surgery to implant acoustic transmitters. In this Opinion, we determined that this level of take is not likely to jeopardize the continued existence of listed species.

This ITS exempts the following lethal take:

- 11 Northwest Atlantic DPS loggerhead sea turtles;
- 2 Kemp's ridley sea turtles;
- 26 shortnose sturgeon;
- 15 New York Bight DPS Atlantic sturgeon;
- 5 Chesapeake Bay DPS Atlantic sturgeon;
- 4 South Atlantic DPS Atlantic sturgeon; and,
- 2 Gulf of Maine DPS Atlantic sturgeon.

The ITS also exempts the capture/collection of up to 1,061 shortnose and 571 NYB DPS Atlantic sturgeon during relocation trawling project to be carried out over the two blasting seasons (December 1, 2015-March 15, 2016; December 1, 2016-March 15, 2017) and the injury (from surgery to install acoustic tags) of up to 70 of those Atlantic sturgeon and 130 of the shortnose sturgeon.

11.2 Reasonable and prudent measures

We believe the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize and monitor impacts of incidental take resulting from the proposed action:

RPMs related to Cutterhead and Hopper Dredging Activities:

1. We must be contacted prior to the commencement of dredging and again upon completion of the dredging activity. This applies to all contracts executed in the initial construction of the 45-foot channel and all subsequent maintenance dredging activities.
2. For cutterhead dredging, an inspector, with sufficient training to identify sturgeon, must be present at the disposal site to conduct daily inspections for biological materials, including shortnose sturgeon, Atlantic sturgeon or sturgeon parts. The inspection schedule and procedures must be sufficient to ensure a high likelihood of documenting entrained sturgeon and must involve inspections of ponded areas and inspections at the area where water is discharged from the disposal site. This requirement applies to the initial construction of the 45-foot channel and all subsequent maintenance dredging activities using a cutterhead dredge, regardless of time of year or reach being dredged.

3. USACE shall ensure that for dredging occurring in Reaches D and E from May 1 – November 15, hopper dredges are outfitted with state-of-the-art sea turtle deflectors on the draghead and operated in a manner that will reduce the risk of interactions with sea turtles.
4. For hopper dredge operations in the reaches AA, A, B, or C, a NMFS-approved observer must be present on board the hopper dredge any time it is operating.
5. For hopper dredge operations in Reaches D and E, a NMFS-approved observer must be present on board the hopper dredge from May 1 – November 15.
6. USACE shall ensure that dredges are equipped and operated in a manner that provides endangered/threatened species observers with a reasonable opportunity for detecting interactions with listed species and that provides for handling, collection, and resuscitation of turtles injured during project activity. Full cooperation with the endangered/threatened species observer program is essential for compliance with the ITS.
7. USACE shall ensure that all measures are taken to protect any turtles or sturgeon that survive entrainment in a hopper dredge.

RPMs related to Blasting and Associated Mechanical Dredging:

8. We must be contacted prior to the commencement of blasting and again upon completion of the blasting and subsequent mechanical dredging activity.
9. Acoustic measurement of the first three detonations must be conducted to confirm the underwater pressure levels estimated by USACE. If pressure levels exceed those estimated in the monitoring plan, USACE must contact us within 24 hours of the recorded measurement.
10. Blasting must be conducted in a manner designed to minimize the potential for fish kills.
11. USACE must implement the NMFS-approved monitoring plan to minimize sturgeon exposure to blasting and ensure that any sturgeon killed during blasting are recorded.
12. An endangered species observer must be present to observe all mechanical dredging activities where debris will be deposited to monitor for any capture of sturgeon.
13. USACE must ensure that all measures are taken to protect any sturgeon that survive capture in the mechanical dredge.

RPMs for Relocation Trawling:

14. USACE must ensure that the trawling is carried out in a way that minimizes the potential for injury or mortality of shortnose and Atlantic sturgeon.

15. All tagging and associated surgery must be carried out in a way that minimizes the potential for long term injury and mortality of shortnose and Atlantic sturgeon.

RPMs for all aspects of the project:

16. USACE must conduct sediment sampling following the completion of dredging and blasting to confirm that substrate type is unchanged following the deepening in Reach B and E. In the unlikely event that it is found that substrate type has changed as a result of the deepening, USACE must work with us to develop an appropriate restoration method to restore substrate types in these reaches.
17. USACE must implement a program to monitor the movement of acoustically tagged Atlantic and shortnose sturgeon during the dredging operations.
18. All Atlantic sturgeon captured must have a fin clip taken for genetic analysis. This sample must be transferred to the archive at USGS.
19. 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 us.
20. Any dead sturgeon must be transferred to an appropriately permitted research facility we will identify so that a necropsy can be undertaken to attempt to determine the cause of death. Sturgeon must be held in cold storage.
21. Any dead sea turtles must be held until proper disposal procedures can be discussed with us. Turtles must be held in cold storage.
22. All sturgeon and turtle captures, injuries, or mortalities associated with the deepening (including blasting) and maintenance activities and any sturgeon and sea turtle sightings in the action area must be reported to us within 24 hours.

11.3 Terms and conditions

In order to be exempt from prohibitions of section 9 of the ESA, USACE must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. To implement RPM #1, USACE must contact us (Zach Jylkka: by email (Zachary.Jylkka@noaa.gov) or phone (978) 282-8467 or (978) 281-9328) within 3 days of the commencement of each dredging cycle (initial construction and maintenance) and again within 3 days of the completion of dredging activity. This correspondence will serve both to alert us of the commencement and cessation of dredging activities and to give us an opportunity to provide USACE with any updated contact information or reporting forms.

2. To implement RPM #2, for cutterhead dredging, USACE must require inspections at the disposal area at least four times a day in order to document any sturgeon entrained in the dredge, including shortnose and Atlantic sturgeon or their parts. USACE must provide training in sturgeon identification to inspectors working at the dredge disposal site. Species identification must be verified by an expert.
3. To implement RPM #2, USACE shall ensure that the disposal site is equipped and operated in a manner that provides the inspector with a reasonable opportunity for detecting interactions with listed species and that provides for handling and collection of listed species during project activity.
4. To implement RPM #3, hopper dredges operating in Reaches D or E from May 1 – November 15, must be equipped with the rigid deflector draghead as designed by the USACE Engineering Research and Development Center, formerly the Waterways Experimental Station (WES), or if that is unavailable, a rigid sea turtle deflector attached to the draghead. Deflectors must be checked and/or adjusted by a designated expert prior to a dredge operation to insure proper installment and operation during dredging. The deflector must be checked after every load throughout the dredge operation to ensure that proper installation is maintained. Since operator skill is important to the effectiveness of the WES-developed draghead, operators must be properly instructed in its use. Dredge inspectors must ensure that all measures to protect sea turtles are being followed during dredge operations.
5. To implement RPM #4, observer coverage on hopper dredges operating in the river (Reaches AA – C) must be sufficient for 100% monitoring of hopper 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 observer must work a shift schedule appropriate to allow the observer to be on watch for at least 50% of the dredge loads (e.g., 12 hours on, 12 hours off). Except in an emergency, cages must not be cleaned out by anyone other than the observer. Any off-watch detections of sea turtles or sturgeon must be recorded and the observer notified as soon as possible. USACE must ensure that USACE dredge operators and/or any dredge contractor adhere to the attached “Monitoring Specifications for Hopper Dredges” with trained NMFS-approved observers, in accordance with the attached “Observer Protocol” and “Observer Criteria” (Appendix B). No observers can be deployed to the dredge site until USACE has written confirmation from us 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, USACE must ensure that our approval is obtained before those observers are deployed on dredges.
6. To implement RPM #5, observer coverage is required on all hopper dredges operating in the Bay (Reaches D and E) during the period of May 1 – November 15. This monitoring coverage must involve the placement of a NMFS-approved observer on board the dredge for every day that dredging is occurring. The observer must work a shift schedule appropriate to allow for the observation of at least 50% of the dredge loads (e.g., 12 hours on, 12 hours off). Except in an emergency, cages must not be cleaned out by anyone

other than the observer. Any off-watch detections of sea turtles or sturgeon must be recorded and the observer notified as soon as possible. USACE must ensure that USACE dredge operators and/or any dredge contractor adhere to the attached “Monitoring Specifications for Hopper Dredges” with trained NMFS-approved observers, in accordance with the attached “Observer Protocol” and “Observer Criteria” (Appendix B). No observers can be deployed to the dredge site until USACE has written confirmation from us 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, USACE must ensure that our approval is obtained before those observers are deployed on dredges.

7. To implement RPM #5, USACE shall require of the dredge operator that, when the observer is off watch, the cage shall not be opened unless it is clogged. USACE shall also require that if it is necessary to clean the cage when the observer is off watch, any aquatic biological material is left in the cage for the observer to document and clear out when they return on duty. In addition, the observer shall be the only one allowed to clean off the overflow screen.
8. To implement RPM #6, if sea turtles are present during dredging or material transport, vessels transiting the area must post a bridge watch, avoid intentional approaches closer than 100 yards when in transit, and reduce speeds to below 4 knots if bridge watch identifies a listed species in the immediate vicinity of the dredge.
9. To implement RPM #6, USACE must ensure that all contracted personnel involved in operating hopper dredges receive thorough training on measures of dredge operation that will minimize takes of sea turtles. Training shall include measures discussed in Appendix B.
10. To implement RPM #7, the procedures for handling live sea turtles must be followed in the unlikely event that a sea turtle survives entrainment in the dredge (Appendix C).
11. To implement RPM #8, each winter that blasting is undertaken, USACE must inform us of the commencement of blasting operations 3 days prior to the actual start date and of the completion date within 3 days after the actual end of operations.
12. To implement RPMs #9, 10, and 11, USACE must review and report upon the success of the monitoring plan following the completion of 2015-2016 blasting season. USACE must share this report with us no later than June 1, 2016 and discuss the need the potential need for improvements to the monitoring plan prior to the start of the 2016-2017 blasting season. If changes to the monitoring plan are necessary, the new plan must be submitted to us no later than August 1, 2016.
13. To implement RPM #9, acoustic monitoring must be conducted on the first day of blasting to verify that sound levels at 140 feet and 500 feet from the blasting is less than or equal to the values estimated by USACE (i.e., peak 120psi, average 70psi at 140 feet, with noise levels below 180dB at 500 feet). Results of this monitoring must be reported

to us prior to any subsequent blasting. This acoustic monitoring must be repeated for a representative sample of all blasts and occur on at least one day per month during both blasting seasons.

14. To implement RPMs #10 and 11, USACE must not commence blasting operations prior to receiving confirmation from us that the blasting plan is acceptable.
15. To implement RPM#11, USACE must work with Atlantic and shortnose sturgeon researchers to monitor the movement of acoustically tagged sturgeon during the blasting operations.
16. To implement RPM#11, USACE must use the DIDSON camera, active acoustic monitoring (VEMCO VR100 receiver or other equivalent technology), and pre-detonation scare charges to ensure that no blasting occur when shortnose or Atlantic sturgeon are detected within 500 feet of the blast site and that the contractor follows all procedures outlined in the plan described in T&C #20.
17. To implement RPM#11, USACE must monitor for injured, stunned, or dead sturgeon following blasting. This plan must include the use of observers to monitor an area with a radius of at least 1,000 feet surrounding the blast site for dead, stunned or injured fish.
18. To implement RPM#12, for mechanical dredging following blasting operations, USACE must require 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 observer must work a shift schedule appropriate to allow for the observation of at least 50% of the dredge loads (e.g., 12 hours on, 12 hours off). The NMFS-approved observer must observe all discharges of dredged material from the dredge bucket to the scow or hopper. All biological material disposed of at the disposal site must be documented by a NMFS-approved observer as outlined in Appendix B). No observers can be deployed to the dredge site until USACE has written confirmation from us 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, USACE must ensure that our approval is obtained before those observers are deployed on dredges.
19. To implement RPM #13, any sturgeon observed in the dredge scow during mechanical dredging operations must be removed with a net and, if alive, returned to the river away from the blasting site.
20. To implement RPM #14, the following measures must be undertaken:
 - a. Location (GPS), temperature, dissolved oxygen (D.O.), capture gear used (e.g., mesh size, trawl), soak time, species captured, and mortalities must be measured and recorded (at the depth fished) each time nets are set. This data must be included in the final report submitted to NMFS.

- b. Gear must be deployed only in waters where D.O. levels > 4.5 mg/L at the deepest depth sampled by the gear for the entire duration of deployment.
 - c. Trawls may be towed at an average speed up to 3.0 knots for up to 15 minutes; however, when anticipating larger catches, towing time should be minimized to limit overdue stress on catches.
 - d. If a trawl (or other gear) becomes snagged on bottom substrate or debris, it must be untangled immediately to reduce potential stress on captured animals.
 - e. To accommodate larger catches, if applicable, researchers must carry secondary net pen(s) in the research vessel; overcrowded fish must be transferred to the spare net pens or else released. Given that sturgeon can suffer from frostbite when held in pens, when air temperatures are below freezing, the net pen must be periodically monitored.
21. To implement RPM #15, the following measures must be undertaken:
- a. When fish are onboard the research vessel for processing, the flow-through holding tank must allow for total replacement of water volume every 15 minutes. Backup oxygenation of holding tanks with compressed oxygen is necessary to ensure sturgeon do not become stressed and D.O. levels remain at or above 4.5 mg/L.
 - b. Any sturgeon overly stressed from capture must be resuscitated and allowed to recover inside net pens or live well; prior to release, it may only be PIT and Floy tagged, weighed, measured and photographed.
 - c. Holding tanks must be cleaned and thoroughly rinsed after use.
 - d. Onboard handling of sturgeon should be minimized, keeping fish in water as much as possible and supporting with a sling or net.
 - e. Prior to release, sturgeon should be examined and, if necessary, recovered by holding fish upright and immersed in river water, gently moving the fish front to back, aiding freshwater passage over the gills to stimulate it. The fish should be released only when showing signs of vigor and able to swim away under its own power. A spotter should watch the fish, making sure it stays submerged and does not need additional recovery.
 - f. When inserting numbered Floy tags, tags must be anchored in the dorsal fin musculature base by inserting forward and slightly downward from the left side to the right through the dorsal pterygiophores.
 - g. Surgical implantation of internal tags must only be attempted when fish are in excellent condition. During surgical procedures, instruments must be sterilized or

changed between uses. To ensure proper closure of surgical incisions, a single interrupted suturing technique should be applied.

- h. Researchers performing anesthesia on sturgeon must have first received supervised training on shortnose or Atlantic sturgeon or another surrogate species before doing so. Only non-stressed animals in excellent health should be anesthetized. To avoid injury while anesthetizing sturgeon in bath treatments, researchers must use restraint (e.g., netting) to prevent animals from jumping or falling out of the container. When inducing anesthesia on sturgeon, researchers must observe fish closely to establish the proper level of narcosis. While performing a surgical procedure, if sudden reflex reaction from an anesthetized fish is encountered, the Researcher must stop the procedure and evaluate the level of anesthesia before proceeding. Researchers must observe sturgeon closely during recovery from anesthesia, ensuring full recovery prior to release.
22. To implement RPM #16, USACE must conduct sediment sampling following the completion of dredging and blasting to confirm that substrate type is unchanged following the deepening in Reach AA, A, B, D, and E. In the unlikely event that it is found that substrate type has changed as a result of the deepening, USACE must work with us to develop an appropriate restoration method to restore substrate types in these reaches. Sediment samples must be taken pre- and post-deepening that are sufficient to document any changes in sediment type. This sampling must include a pre- and post-blasting survey of hard bottom habitat in Marcus Hook after both blasting seasons to document any unanticipated loss of hard bottom habitat in the area. The survey results of the post-blasting hard bottom habitat must be provided to us within 60 days of survey completion. Should it be found that substrate type has changed as a result of the deepening (including blasting), USACE must work with us to develop an appropriate restoration method to restore substrate types in this reach.
23. To implement RPM#17, USACE must work with Atlantic and shortnose sturgeon researchers to monitor the movement of acoustically tagged sturgeon during dredging operations. The monitoring program must provide coverage of one full dredge cycle in each affected reach during the initial construction period and one full dredge cycle in each affected reach during the maintenance period. The monitoring program must also cover one dredge cycle with a hopper dredge in Reach AA, A, B or C and one dredge cycle with a hopper dredge in Reach D or E. Preliminary reports containing information on the number of tagged sturgeon detected and their movements must be provided to us within 90 days of the completion of dredging. This term and condition does not require USACE to tag any sturgeon with telemetry tags.
24. To implement RPM #18, USACE must ensure that fin clips are taken (according to the procedure outlined in Appendix D) of any Atlantic sturgeon captured during the project (including relocation trawling) and that the fin clips are sent to USGS for genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies. USACE is responsible for the cost of the genetic analysis.

25. To implement RPM #19, all collected sturgeon must be inspected for a PIT tag with an appropriate PIT tag reader. Any tag numbers must be recorded and reported to us.
26. To implement RPM #20, in the event of any lethal takes of shortnose or Atlantic sturgeon, any dead specimens or body parts must be photographed, measured, and preserved (refrigerate or freeze) until disposal procedures are discussed with us. The form included as Appendix E (sturgeon incident form) must be completed and submitted to us. USACE is responsible for the cost of any necropsies.
27. To implement RPM #21, in the event of any lethal takes of sea turtles, any dead specimens or body parts must be photographed, measured, and preserved (refrigerate or freeze) until disposal procedures are discussed with us. Genetic samples must be taken as described in Appendix F.
28. To implement RPM #21, if a decomposed turtle or turtle part is entrained during dredging operations, an incident report must be completed and the specimen must be photographed. Any turtle parts that are considered 'not fresh' (i.e., they were obviously dead prior to the dredge take and USACE anticipates that they will not be counted towards the ITS) must be frozen and transported to a nearby stranding or rehabilitation facility for review. USACE must ensure that the observer submits the incident report for the decomposed turtle part, as well as photographs, to us within 24 hours of the take (see Appendix E) and request concurrence that this take should not be attributed to the Incidental Take Statement. We shall have the final say in determining if the take should count towards the Incidental Take Statement.
29. To implement RPM #22, USACE must contact us within 24 hours of any interactions with sturgeon or sea turtles, including non-lethal and lethal takes. If the interaction with sturgeon is a result of relocation trawling, USACE must contact us weekly (not within 24 hours) to report on how many sturgeon were captured and where they were relocated to. A summary take report for sturgeon relocation trawling must be provided to us at the conclusion of each blasting season (no later than June 1, 2016 and June 1, 2017, respectively). We will provide contact information annually when alerted of the start of dredging activity. Until alerted otherwise, USACE should contact Zach Jylkka: by email (zachary.jylkka@noaa.gov) or phone (978) 282-8467 or the Endangered Species Coordinator by phone (978) 282-8480 or fax (978) 281-9394). Take information should also be reported by e-mail to: incidental.take@noaa.gov.
30. To implement RPM #22, the USACE must photograph and measure any sturgeon (not including sturgeon captured with minor injuries related to relocation trawling) or sea turtles observed during project operations (including whole sturgeon or sea turtles or body parts observed at the disposal location or on board the dredge, hopper or scow) and the corresponding form (Appendix E) must be completed and submitted to us **within 24 hours** by fax (978) 281-9394) or e-mail: incidental.take@noaa.gov.
31. To implement RPM #22, any time a take occurs (not including capture and minor injuries of sturgeon related to relocation trawling) USACE must immediately contact us

to review the situation. At that time, USACE must provide us with information on the amount of material dredged thus far and the amount remaining to be dredged during that cycle. Also at that time, USACE should discuss with us whether any new management measures could be implemented to prevent the total incidental take level from being exceeded and will work with us to determine whether this take represents new information revealing effects of the action that may not have been previously considered.

32. To implement RPM #22, USACE must submit a final report summarizing the results of dredging and any takes of listed species to us within 30 working days of the completion of each dredging contract (by mail to the attention of the Section 7 Coordinator, NMFS Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930). This report must be submitted at the close of each dredging contract during construction of the 45 foot channel as well as each time maintenance dredging is required.

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 keep us informed of when and where dredging and blasting activities are taking place and will require USACE to report any take in a reasonable amount of time, as well as implement measures to monitor for entrainment during dredging and avoid conducting blasting activities when sturgeon are in the immediate area surrounding the blast site. The discussion below explains why each of these RPMs and Terms and Conditions are necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the action as proposed by the USACE.

RPM #1 and #8 and Term and Condition #1 and #11 are necessary and appropriate because they will serve to ensure that we are aware of the dates and locations of all dredging and blasting activities. This will allow us to monitor the duration and seasonality of dredging activities as well as give us an opportunity to provide USACE with any updated contact information for our 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 USACE and our staff.

Several of the RPMs (#2,4, 5, and 12) as well as the implementing Term and Conditions (#2, 3, 5,6,7, and 18) are necessary and appropriate because they require that USACE have sufficient observer coverage to ensure the detection of any interactions with listed species. 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 USACE included some level of observer coverage in the original project description and the increase in coverage (i.e., the addition of the month of May for hopper dredges operating in the Bay, the addition of observers for hopper dredges operating in the river) will represent only a small increase in the cost of the project and 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 inspectors or observers.

RPM #3 and Term and Condition #4, are necessary and appropriate as the use of draghead deflectors is accepted standard practice for hopper dredges operating in places and at times of year when sea turtles are known to be present and has been documented to reduce the risk of

entrainment for sea turtles, thereby minimizing the potential for take of these species. This represents only a minor change as all of the hopper dredges likely to be used for this project, including the USACE owned McFarland which may be used for maintenance dredging, already have draghead deflectors, dredge operators are already familiar with their use, and the use will not affect the efficiency of the dredging operation. Additionally, maintenance of the existing channel is conducted with draghead deflectors in place.

RPM #6 and Term and Conditions #8 and 9 are necessary and appropriate as they will require that dredge operators use best management practices, including slowing down to 4 knots should listed species be observed, that will minimize the likelihood of take. This represents only a minor change as following these procedures should not increase the cost of the dredging operation or result in any delays of reduction of efficiency of the dredging project.

RPM #7 and #13 and Term and Condition #10 and 19 are necessary and appropriate to ensure that any sea turtles or sturgeon that survive entrainment in a hopper dredge or 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 #8-11 and their implementing Terms and Conditions #11-17 are necessary and appropriate to minimize the potential for blasting activities to take place when sturgeon are within 500 feet of the detonation site. These conditions are also designed to verify that the sound and pressure levels presented by USACE and that we rely on in estimating take are valid and that a 500 foot exclusion zone is sufficient. This does not cause more than minor changes because it merely provides additional clarification to the requirement already imposed by USACE to conduct underwater monitoring of pressure levels associated with blasting. The clarification of the already required pressure monitoring and the inclusion of sound monitoring will not cause delays to the project or add a significant cost. The monitoring plan represents only a minor change as the plan to be implemented will be designed by USACE in cooperation with us and is not anticipated to result in any increased cost, delays of the project or decreased efficiency of blasting operations. Further, the plan will not alter the time of year or location of detonation sites.

RPM #14 and 15 and Terms and Conditions #20-21 are necessary and appropriate as they will serve to ensure that sturgeon captured in relocation trawling have a minimized risk of long term injury and mortality during tagging and relocation. This represents only a minor change as following these procedures should not increase the cost of the dredging operation or result in any delays of reduction of efficiency of the dredging project

RPM #16 and Term and Condition #22 are necessary and appropriate as they will serve to verify USACE's determination that deepening (including blasting) will not alter the substrate type in any reach of the river. The monitoring plan represents only a minor change as some post-construction monitoring is already planned. Also, any necessary restoration will be designed by USACE in cooperation with us and is not anticipated to result in any delays of the project or

changes to dredging operations.

RPM #17 and Term and Condition #23 are necessary and appropriate as they will serve to monitor the movements of tagged sturgeon during dredging. A successful study was carried out in 2011; the continuation of a similar study in different river reaches and at different times of year will serve to verify assumptions made by us and USACE regarding the movements of sturgeon near operating dredges, which were based on the 2011 study and other similar studies. The monitoring plan represents only a minor change as it will not result in any delays to dredging or modifications of the dredge plan and any increased cost will be very small in comparison to the total costs of the project.

RPM #18-22 and Terms and Conditions #24-31 are necessary and appropriate to ensure the proper handling and documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. This is essential for monitoring the level of incidental take associated with the proposed action. Genetic analysis must be conducted on Atlantic sturgeon samples to determine the appropriate DPS of origin and accurately record take of this species. These RPMs and Terms and Conditions represent only a minor change as compliance will not result in any increased cost, delay of the project or decrease in the efficiency of the dredging operations.

12.0 CONSERVATION RECOMMENDATIONS

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

- (1) To the extent practicable, USACE should avoid dredging during times of year when listed species are likely to be present.
- (2) Population information on certain life stages of shortnose sturgeon is still sparse for this river system. USACE should continue to support studies to evaluate habitat and the use of the river, in general, by juveniles as well as use of the area below Philadelphia by all life stages. Population estimates are also lacking for Atlantic sturgeon. USACE should continue to support studies to assist in gathering the necessary information to develop a population estimate for the NYB DPS (as well as other Atlantic sturgeon DPSs).
- (3) If any lethal take occurs, USACE should arrange for contaminant analysis of the specimen. If this recommendation is to be implemented, the fish should be immediately frozen and we should be contacted within 24 hours to provide instructions on shipping and preparation.

- (4) USACE should conduct studies at the upland dredged material disposal areas to assess the potential for improved screening to: (1) establish the type and size of biological material that may be entrained in the cutterhead dredge, and (2) verify that monitoring the disposal site without screening is providing an accurate assessment of entrained material.
- (5) If a hopper dredge is used outside of Reaches D and E, USACE should consider using a dredge equipped with the rigid deflector draghead as designed by USACE Engineering Research and Development Center, formerly the Waterways Experimental Station or, if that is unavailable, a rigid sea turtle deflector attached to the draghead. While sea turtles are unlikely to occur in these reaches, the sea turtle deflector may also work to reduce the number of interactions between the dredge and sturgeon.
- (6) USACE should support studies to determine the effectiveness of using a sea turtle deflector to minimize the potential entrainment of sturgeon during hopper dredging.

13.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the proposal by USACE to deepen the Delaware River Philadelphia to the Sea federal navigation 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.

Historical Take Records of Sturgeon

Sturgeon Take Records from Dredging Operations 1990 - Mar 2012										
Take #	Date	Corps District	Location	Sp	Dredge Type/Name	Status	Specimen Description	Notes	Photos	Documentation
1	30 Oct 90	SAC	Winyah Bay Georgetown	A	H <i>Ouchita</i>	Dead	~69cm, rear half	Overflow Screening	N	Chris Slay pers com Observer report DACW 60-90-C-0067
2	15 Jan 94	SAS	Savannah Harbor	A	H <i>RN Weeks</i>	NA	NA	Found by Turtle observer	No	Steve Calver pers com 14 Jun 05 Observer load sheet and final rpt #DACW21-93-C-0072
3	07 Dec 94	SAS	Savannah Harbor	A	H <i>Dodge Island</i>	Live released	71cm, whole fish	Starboard Skimmer Screening	Yes We have efile	Chris Slay pers com Observer report
4	07 Dec 94 Different Load	SAS	Savannah Harbor	A	H <i>Dodge Island</i>	Dead	77.5cm, whole fish	Starboard Skimmer Screening	Yes We have efile	Chris Slay pers com Observer report
5	Feb 96	NAP	Delaware River Newbold Island	S	P <i>Ozark</i>	Dead	83cm, female w/eggs	In DMA Money Island		NMFS memo for record From Laurie Silva 19 Apr 96
6	Feb 96	NAP	Delaware River Newbold Island	S	P <i>Ozark</i>	Dead	63cm, mature male	In DMA Money Island		NMFS memo for record From Laurie Silva 19 Apr 96
7	06 Jan 98	NAP	Delaware River Kinkora Range	S	P ??	Dead	Either 657mm or 573mm ???	In DMA Money Island	Y Not e-file	Memo for file 20 Jan 98 From Greg Wack NAP
8	12 Jan 98	NAP	Delaware River Florence Range	S	P ??	Dead	Either 657mm or 573mm ???	In DMA Money Island	Y Not e-file	Memo for file 20 Jan 98 From Greg Wack NAP
9	13 Jan 98	NAP	Delaware River Florence Range	S	P ??	Dead	Either 657mm or 573mm ???	In DMA Money Island	Y Not e-file	Memo for file 20 Jan 98 From Greg Wack NAP
10	7 Sep 98	SAW	Wilmington Har Cape Fear River	A	H <i>McFarland</i>	Dead	Head only (1 ft long)	In turtle Inflow screen		Observer incident report Pers com Bill Adams- SAW 26 Jul 04
11	01 Mar 00	SAC	Charleston Harbor	A	H <i>Snyvesant</i>	Dead	Missing head and tail	Main Overflow Screening	No	Chris Slay pers com Observer reporting forms
12	12 Apr 00	SAC	Charleston Harbor	A	H <i>Snyvesant</i>	Dead	71.6cm, whole fish	Starboard Overflow screening	No	Chris Slay pers com Observer reporting forms
13	03 Dec 00	SAW	Wilmington Har MOTSU	A	C <i>New York</i>	Dead	82.5cm, whole fish decomposing	In bucket	Y Not e-file Payonk?	Chris Slay pers com Phil Payonk pers com 30 Jul 04 Bill Adams pers com 28 Jul 04 #DACW54-00-C-0013

Sturgeon Take Records from Dredging Operations 1990 - Mar 2012

Take #	Date	Corps District	Location	Sp	Dredge Type/ Name	Status	Specimen Description	Notes	Photos	Documentation
14	24 Feb 01	SAS	Brunswick Harbor	A	H <i>RN Weeks</i>	Dead	Head only	Just mentions take on all forms, no other info.	No	Daily and Weekly Reports, Load sheet.
15	19 Jun 01	NAE	Kennebec River Bath Iron Works	A	C ??	Live released		Put in scow, released unharmed		Julie Crocker NMFS pers com 19 Jul 04 2003 Chesapeake BA, Section 7.2 Normandeau Associates, Inc 2001
16	30 Apr 03	NAE	Kennebec River Bath Iron Works	S	C Reed and Reed dredge company	Dead	Fish nearly cut in half		Y We have e-file	Julie Crocker NMFS pers com 19 Jul 04 2003 Chesapeake BA, Section 7.2 Normandeau Associates, Inc 2001
17	6 Oct 03	NAE	Kennebec River Doubling Point	S	H <i>Padre Island</i>	Dead	38.1 inches	In hopper	Y We have e-file	Observer incident report Kennebec River BA Jul 04 Memo for Commander, from Bill Kavanaugh, 1 Jul 04 Bill Kavanaugh pers com 15 Jul 04 Julie Crocker pers com 19 Jul 04
18	6 Oct 03	NAE	Kennebec River Doubling Point	S	H <i>Padre Island</i>	Dead	37.0 inches	In hopper Did not dive Probably died	Y We have e-file	Observer incident report Kennebec River BA Jul 04 Memo for Commander, from Bill Kavanaugh, 1 Jul 04 Bill Kavanaugh pers com 15 Jul 04 Julie Crocker pers com 19 Jul 04
19	6 Oct 03	NAE	Kennebec River Doubling Point	S	H <i>Padre Island</i>	Live	Swam away	In hopper	Y We have e-file	Observer incident report Kennebec River BA Jul 04 Memo for Commander, from Bill Kavanaugh, 1 Jul 04 Bill Kavanaugh pers com 15 Jul 04 Julie Crocker pers com 19 Jul 04

Sturgeon Take Records from Dredging Operations 1990 - Mar 2012

Take #	Date	Corps District	Location	Sp	Dredge Type/ Name	Status	Specimen Description	Notes	Photos	Documentation
20	06 Oct 03	NAE	Kennebec River Doubling Point	S	H <i>Padre Island</i>	Dead	Found alive	In hopper	Y We have e-file	Observer incident report Kennebec River BA Jul 04 Memo for Commander, from Bill Kavanaugh, 1 Jul 04 Bill Kavanaugh pers com 15 Jul 04 Julie Crocker pers com 19 Jul 04
21	08 Oct 03	NAE	Kennebec River Doubling Point	S	H <i>Padre Island</i>	Live	Good condition	In hopper	Y We have e-file	Observer incident report Kennebec River BA Jul 04 Memo for Commander, from Bill Kavanaugh, 1 Jul 04 Bill Kavanaugh pers com 15 Jul 04 Julie Crocker pers com 19 Jul 04
22	07 Jan 04	SAC	Charleston Harbor	A	H <i>Manhattan Island</i>	Live	Whole fish 49 inches total length May have died later when released	Found by Coastwise turtle observers	Yes (We Have e-file)	Robert Chappell pers com 28 Jun 04 Observer daily report 7 Jan 04
23	13 Dec 04	SAM	Gulfport Harbor Channel	G	H <i>Bayport</i>	Dead	Trunk of fish 59.5cm	Found by turtle observers		Observer incident report Susan Rees pers com 7 Jan 05
24a	28 Dec 04	SAM	Mobile Bar Channel	G	H <i>Padre Island</i>	Dead	Trunk of fish 2 ft, 1inch	Found by Turtle observers	Yes (We Have e-file)	Observer incident report Susan Rees pers com 7 Jan 05 #W91278-04-C-0049
24b	01 Jan 05	SAM	Mobile Bar Channel	G	H <i>Padre Island</i>	Dead	Head only of fish 22.5cm	2 nd part of take on 28 Dec 04	Yes taken But we Have not received	Observer incident report Susan Rees pers com 7 Jan 05 #W91278-04-C-0049
25	2 Mar 05	SAS	Brunswick Harbor	A	H <i>RN Weeks</i>	Dead	Posterior section only 60 cm section w/tail	Found by turtle observer	Yes (We Have e-file)	Chris Slay pers com 7 Jun 05 Steve Calver pers com 14 Jun 05
26	26 Dec 06	SAS	Brunswick	A	H <i>Newport</i>	Dead	Head only	Caught in port screen and	Black and	Incident and load report

Sturgeon Take Records from Dredging Operations 1990 - Mar 2012

Take #	Date	Corps District	Location	Sp	Dredge Type/ Name	Status	Specimen Description	Notes	Photos	Documentation
								turtle part caught in starboard screen	White	
27	17 Jan 07	SAS	Savannah Entrance Channel	A	H <i>Glenn Edwards</i>	Dead	Whole fish, FL 104 cm	Fresh Dead, 60 Horseshoe crab in with load	Coastwise took photo	Incident and Load report
28	2 Mar 09	SAS	Savannah Entrance Channel	A	H <i>Dodge Island</i>	Dead	Total Length 111 cm	Fresh Dead, found in starboard aft inflow box, load #42		Incident, Load and Daily report
29	6 Feb 10	SAS	Brunswick Entrance Channel	A	H <i>Glenn Edwards</i>	Dead	No measurements	Fore screen contents, Load #19 with 12 Horseshoe crab		No incident report, just listed on load sheet and daily summary
30	7 Feb 10	SAS	Brunswick Entrance Channel	A	H <i>Glenn Edwards</i>	Dead	No measurements	Fore screen contents, Load #25 with 20 Horseshoe crab		No incident report, just listed on load sheet and daily summary
31	2 Feb 10	SAS	Brunswick Entrance Channel	A	H <i>Bayport</i>	Dead	No measurements, head to mid body in load #193 and mid body to tail recovered in load #194.	Stbd screen contents, load #193 and overflow screen in #194,		No incident report, just listed on load sheet and daily summary
32	7 Dec 10	SAW	Wilmington Harbor	A	H Terrapin Island	Dead	Whole fish, FL 61 cm	Fresh Dead, water temp 12 C, air 2 C, load 6	Coastwise took photo	Incident and Load report
33	10 Apr 11	NAO	York Spit Channel	A	H Terrapin Island	Dead	Total Length 24.5" in, Fork Length 13.5", Middle of anus to Anal Fin 3.8"	During Clean up. Torn in half, only posterior from pectoral region to tail, no head. Fins and tail torn but complete		Hopper daily report from, QCR, e-mail, incident report, daily report, load sheets

Sturgeon Take Records from Dredging Operations 1990 - Mar 2012

Take #	Date	Corps District	Location	Sp	Dredge Type/ Name	Status	Specimen Description	Notes	Photos	Documentation
34	11Apr 11	NAO	York Spit Channel	A	H Liberty Island	Dead		During cleanup. Another piece taken on 4/13/11 matches perfectly.	Y	E-mail
35	14 Mar 12	SAC	Charleston Harbor Channel	A	H Glenn Edwards	Dead	Fresh dead, body part 26"-30" long X 13" width, no head or tail	Load 129 (0024-0345) found in starboard draghead, during cleanup mode. Given to South Carolina DNR	Yes	E-mail, load sheet, incident report
NT	25 May 05	NAO	York Spit Channel	?	H <i>McFarland</i>	Dead	Approx. 2 ft estimate from photos	Too decomposed to identify	Yes (We Have e-file)	Observer final report, REMSA 2004
NDNEF	26 Jun 96	NAN	East Rock Away Long Island	?	H Dodge Island	Dead	(~3'), couldn't identify and doesn't mention condition (fresh or dead already)? Chris Starbird.	Load sheet states Carp or sturgeon	No	Load sheet, Daily and Weekly Summary mentions. No way to confirm.
NDNEF	About 98	SAW	Wilmington Har Cape Fear River	A	P ??	Dead				NMFS 1998 Shortnose Recovery Plan p. 53
NDNEF	About 98	SAW	Wilmington Har Cape Fear River	A	C	Dead				NMFS 1998 Shortnose Recovery Plan p. 53
NDNEF	About 98	SAJ or SAS	Kings Bay	A	H ??	Dead				NMFS 1998 Shortnose Recovery Plan p. 52 Chris Slay pers com

Sp=sturgeon species

A=Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)

S=Shortnose sturgeon (*Acipenser brevirostrum*)

G=Gulf sturgeon (*Acipenser oxyrinchus desotoi*)

NT = Non-take incident by dredge

SAC=Charleston

SAW=Wilmington
SAS=Savannah
SAJ=Jacksonville
SAM=Mobile
NAE=New England
NAO=Norfolk
NAN=New York
NAP=Philadelphia
H=Hopper
P=Hydraulic Cutterhead pipeline
C=Mechanical clamshell or bucket, bucket and barge
DMA=Dredged material disposal area
NDNEF=No documentation, no evidence found to confirm citation

APPENDIX B.

MONITORING SPECIFICATIONS FOR DREDGES

Part 1. – HOPPER DREDGES

I. EQUIPMENT SPECIFICATIONS

A. Baskets or screening

Baskets or screening must be installed over the hopper inflows with openings no smaller than 4 inches by 4 inches to provide 100% coverage of all dredged material and shall remain in place during all dredging operations. Baskets/screening will allow for better monitoring by observers of the dredged material intake for sea turtles, sturgeon and their remains. The baskets or screening must be safely accessible to the observer and designed for efficient cleaning.

B. Draghead

The draghead of the dredge shall remain on the bottom **at all times** during a pumping operation, except when:

- 1) the dredge is not in a pumping operation, and the suction pumps are turned completely off;
- 2) the dredge is being re-oriented to the next dredge line during borrow activities; and
- 3) the vessel's safety is at risk (i.e., the dragarm is trailing too far under the ship's hull).

At initiation of dredging, the draghead shall be placed on the bottom during priming of the suction pump. If the draghead and/or dragarm become clogged during dredging activity, the pump shall be shut down, the dragarms raised, whereby the draghead and/or dragarm can be flushed out by trailing the dragarm along side the ship. If plugging conditions persist, the draghead shall be placed on deck, whereby sufficient numbers of water ports can be opened on the draghead to prevent future plugging.

Upon completion of a dredge track line, the drag tender shall:

- 1) throttle back on the RPMs of the suction pump engine to an idling speed (e.g., generally less than 100 RPMs) **prior to** raising the draghead off the bottom, so that no flow of material is coming through the pipe into the dredge hopper. Before the draghead is raised, the vacuum gauge on the pipe should read zero, so that no suction exists both in the dragarm and draghead, and no suction force exists that can impinge a turtle on the draghead grate;
- 2) hold the draghead firmly on the bottom with no flow conditions for approximately 10 to 15 seconds before raising the draghead; then, raise the draghead quickly off the bottom and up to a mid-water column level, to further reduce the potential for any adverse interaction with nearby turtles;

- 3) re-orient the dredge quickly to the next dredge line; and
- 4) re-position the draghead firmly on the bottom prior to bringing the dredge pump to normal pumping speed, and re-starting dredging activity.

C. Floodlights

Floodlights must be installed to allow the NMFS-approved observer to safely observe and monitor the baskets or screens.

D. Intervals between dredging

Sufficient time must be allotted between each dredging cycle for the NMFS-approved observer to inspect and thoroughly clean the baskets and screens for sea turtles and/or turtle parts and document the findings. Between each dredging cycle, the NMFS-approved observer should also examine and clean the dragheads and document the findings.

II. OBSERVER PROTOCOL

A. Basic Requirement

A NMFS-approved observer with demonstrated ability to identify sea turtle and sturgeon species 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 entrained or present in the vicinity of dredge operations.

B. Duty Cycle

Observers are required at times and locations outlined in the ITS. While onboard, the observer must work a shift schedule appropriate to allow for the observation of at least 50% of the dredge loads (e.g., 12 hours on, 12 hours off). The USACE shall require of the dredge operator that, when the observer is off watch, the cage shall not be opened unless it is clogged. The USACE shall also require that if it is necessary to clean the cage when the observer is off watch, any aquatic biological material is left in the cage for the observer to document and clear out when they return on duty. In addition, the observer shall be the only one allowed to clean off the overflow screen.

C. Inspection of Dredge Spoils

During the required inspection coverage, the trained NMFS-approved observer shall inspect the galvanized screens and baskets at the completion of each loading cycle for evidence of sea turtles or shortnose sturgeon. The Endangered Species Observation Form shall be completed for each loading cycle, whether listed species are present or not. If any whole (alive or dead) or turtle parts are taken incidental to the project(s), NMFS Protected Resources Division must be contacted by phone (978-281-9328) or e-mail (incidental.take@noaa.gov) within 24 hours of the take. An incident report for sea turtle/shortnose sturgeon take (Appendix E) shall also be completed by the observer and sent via FAX (978) 281-9394 or e-mail (incidental.take@noaa.gov) within 24 hours of the take. Incident reports shall be completed for

every take regardless of the state of decomposition. NMFS will determine if the take should be attributed to the incidental take level, after the incident report is received. Every incidental take (alive or dead, decomposed or fresh) should be photographed, and photographs shall be sent to NMFS either electronically (incidental.take@noaa.gov) or through the mail. Weekly reports, including all completed load sheets, photographs, and relevant incident reports, as well as a final report, shall be submitted to NMFS NER, Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930-2298.

D. Information to be Collected

For each sighting of any endangered or threatened marine species (including whales as well as sea turtles), record the following information on the Endangered Species Observation Form (Appendix E):

- 1) Date, time, coordinates of vessel
- 2) Visibility, weather, sea state
- 3) Vector of sighting (distance, bearing)
- 4) Duration of sighting
- 5) Species and number of animals
- 6) Observed behaviors (feeding, diving, breaching, etc.)
- 7) Description of interaction with the operation

E. Disposition of Parts

If any whole turtles or sturgeon (alive or dead, decomposed or fresh) or turtle or shortnose sturgeon parts are taken incidental to the project(s), NMFS Protected Resources must be contacted within 24 hours of the take (phone: 978-281-9328 or e-mail (incidental.take@noaa.gov)). All whole dead sea turtles or sturgeon, or turtle or shortnose sturgeon parts, must be photographed and described in detail on the Incident Report of Sea Turtle Mortality (Appendix E). The photographs and reports should be submitted by email (incidental.take@noaa.gov) or mail (Attn: Section 7 Coordinator, NMFS, Protected Resources Division, 55 Great Republic Drive, Gloucester, MA 01930-2298). After NMFS is notified of the take, it may instruct the observer to save the animal for future analysis if there is freezer space. Disposition of dead sea turtles/ sturgeon will be determined by NMFS at the time of the take notification. If the species is unidentifiable or if there are entrails that may have come from a turtle, the subject should be photographed, placed in plastic bags, labeled with location, load number, date and time taken, and placed in cold storage.

Live turtles (both injured and uninjured) should be held onboard the dredge until transported as soon as possible to the appropriate stranding network personnel for rehabilitation (Appendix C). No live turtles should be released back into the water without first being checked by a qualified veterinarian or a rehabilitation facility. The NMFS Stranding Network Coordinator ((978) 282-8470) should also be contacted immediately for any marine mammal injuries or mortalities.

III. 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 leatherback (*Dermochelys coriacea*), loggerhead *Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*) turtles and their parts, and shortnose (*Acipenser brevirostrum*) and Atlantic (*Acipenser oxyrinchus oxyrinchus*) sturgeon and their parts;
- 2) handle live sea turtles and sturgeon and resuscitate and release them according accepted procedures;
- 3) correctly measure the total length and width of live and whole dead sea turtle and sturgeon species;
- 4) observe and advise on the appropriate screening of the dredge's overflow, skimmer funnels, and dragheads; and
- 5) identify marine mammal species and behaviors.

B. Training

Ideally, the applicant will have educational background in marine 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, the below observer training is necessary to be considered admissible by NMFS. We can assist the USACE 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 sea turtles and sturgeon and their parts;
- 2) instruction on appropriate screening on hopper dredges for the monitoring of sea turtles and sturgeon (whole or parts);
- 3) demonstration of the proper handling of live sea turtles and sturgeon incidentally captured during project operations. Observers may be required to resuscitate sea turtles according to accepted procedures prior to release;
- 4) instruction on standardized measurement methods for sea turtle and sturgeon lengths and widths; and

- 5) instruction on how to identify marine mammals; and
- 6) instruction on dredging operations and procedures, including safety precautions onboard a vessel.

Part 2. 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 observer 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 must be contacted **within 24 hours** of the take (phone: 978-281-9328 or email (incidental.take@noaa.gov)). 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 (incidental.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 refrigerated or frozen until disposition can be discussed with NMFS. Under no circumstances should dead sturgeon be disposed of without confirmation of disposition details with NMFS.

III. 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 USACE 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

Sea Turtle Handling and Resuscitation

It is unlikely that sea turtles will survive entrainment in a hopper dredge, as the turtles found in the dragheads are usually dead, dying, or dismantled. However, the procedures for handling live sea turtles follow in case the unlikely event should occur. These guidelines are adapted from 50 CFR § 223.206(d)(1).

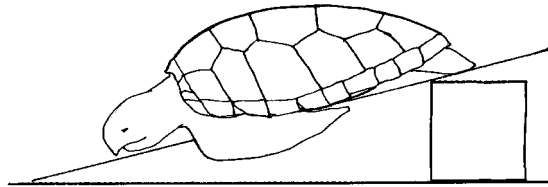
Please photograph all turtles (alive or dead) and turtle parts found during dredging activities and complete the Incident Report of Sea Turtle Take.

Live sea turtles

- When a sea turtle is found in the dredge gear, observe it for activity and potential injuries.
- **If the turtle is actively moving**, it should be retained onboard until evaluated for injuries by a permitted rehabilitation facility. Due to the potential for internal injuries associated with hopper entrainment, it is necessary to transport the live turtle to the nearest rehabilitation facility as soon as possible, following these steps:
- Contact the nearest rehabilitation facility to inform them of the incident. If the rehabilitation personnel cannot be reached immediately, please contact NMFS stranding hotline at 866-755-6622 or NMFS Sea Turtle Stranding Coordinator at 978-281-9328.
- Keep the turtle shaded and moist (e.g., with a water-soaked towel over the eyes, carapace, and flippers), and in a confined location free from potential injury.
- Contact the crew boat to pick up the turtle as soon as possible from the dredge (within 12 to 24 hours maximum). The crew boat should be aware of the potential for such an incident to occur and should develop an appropriate protocol for transporting live sea turtles.
- Transport the live turtle to the closest permitted rehabilitation facility able to handle such a case.
- Do not assume that an inactive turtle is dead. The onset of rigor mortis and/or rotting flesh are often the only definite indications that a turtle is dead. Releasing a comatose turtle into any amount of water will drown it, and a turtle may recover once its lungs have had a chance to drain.
- **If a turtle appears to be comatose** (unconscious), contact the designated stranding/rehabilitation personnel immediately. Once the rehabilitation personnel has been informed of the incident, attempts should be made to revive the turtle at once. Sea turtles have been known to revive up to 24 hours after resuscitation procedures have been followed.

- Place the animal on its bottom shell (plastron) so that the turtle is right side up and elevate the hindquarters at least 6 inches for a period of 4 up to 24 hours. The degree of elevation depends on the size of the turtle; greater elevations are required for larger turtles.
- Periodically, rock the turtle gently left to right and right to left by holding the outer edge of the shell (carapace) and lifting one side about 3 inches then alternate to the other side.
- Periodically, gently touch the eye and pinch the tail (reflex test) to see if there is a response.

- Keep the turtle in a safe, contained place, shaded, and moist (e.g., with a water-soaked towel over the eyes, carapace, and flippers) and observe it for up to 24 hours.
- If the turtle begins actively moving, retain the turtle until the appropriate rehabilitation personnel can evaluate the animal. The rehabilitation facility should eventually release the animal in a manner that minimizes the chances of re-impingement and potential harm to the animal (i.e., from cold stunning).
- Turtles that fail to move within several hours (up to 24) must be handled in the manner described, or transported to a suitable facility for necropsy (if the condition of the sea turtle allows and the rehabilitation facility wants to necropsy the animal).



Stranding/rehabilitation contacts

- **NMFS Stranding Hotline:** 866-755-6622 or NERStranding.staff@noaa.gov

APPENDIX D

**ENDANGERED SPECIES OBSERVER FORM
Delaware River FNP Dredging - Daily Report**

Date: _____

Dredge Vessel Name _____

Hopper Cutterhead Mechanical

Observer Location: On Board Dredge Disposal Site

Reach being Dredged: _____

Disposal Site: _____

Dredge Location: Lat/Long _____

River Mile: _____ Reach: _____ Range: _____

Weather conditions: _____

Water temperature: Surface _____ Below midwater (if known) _____

Condition of screening apparatus: _____

Incidents involving endangered or threatened species? (Circle) Yes No
(If yes, fill out Appropriate Incident Report and transmit to NMFS within 24 hours)

Comments (type of material, biological specimens, unusual circumstances, etc.):

Observer's Name: _____

Observer's Signature: _____

<u>Species</u>	<u># of Sightings</u>	<u># of Animals</u>	<u>Comments</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Incident Report of Sea Turtle Take

Date _____ Time (specimen found) _____

Species _____

Geographic Site _____

Location: Lat/Long _____

Vessel Name _____ Load # _____

Begin load time _____ End load time _____

Begin dump time _____ End dump time _____

Condition of screening _____

Location where specimen recovered _____

Draghead deflector used? YES NO Rigid deflector draghead? YES NO

Condition of deflector _____

Weather conditions _____

Water temp: Surface _____ Below midwater (if known) _____

Species Information: *(please designate cm/m or inches.)*

Head width _____ Plastron length _____

Straight carapace length _____ Straight carapace width _____

Curved carapace length _____ Curved carapace width _____

Condition of specimen/description of animal (please complete attached diagram)

Turtle Decomposed: NO SLIGHTLY MODERATELY SEVERELY

Turtle tagged: YES NO *Please record all tag numbers.* Tag # _____

Genetic sample taken: YES NO

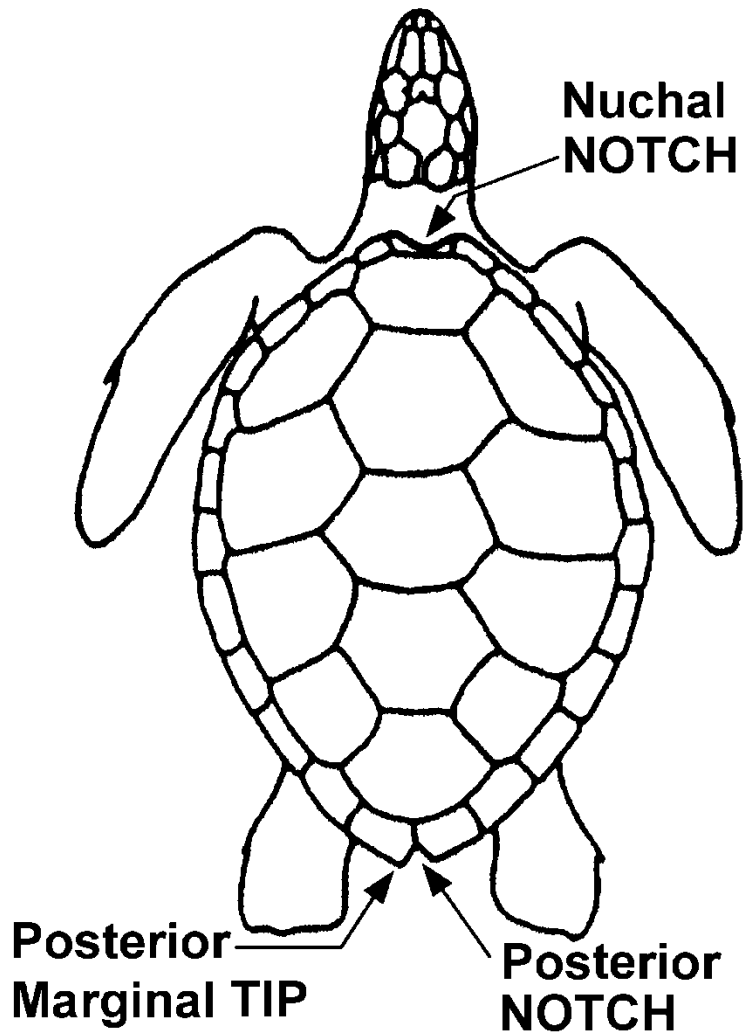
Photograph emailed to NMFS: YES NO

Comments/other (include justification on how species was identified) _____

Observer's Name _____ Observer's Signature _____

Incident Report of Sea Turtle Take

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



Description of animal:

Incident Report of Sturgeon Take

Photographs should be taken and the following information should be collected from all sturgeon (alive and dead)

Date _____ Time (specimen found) _____

Geographic Site _____

Location: Lat/Long _____

Dredge Vessel Name _____

Disposal Site _____

Begin dredge time _____

End dredge time _____

HOPPER MECHANICAL CUTTERHEAD

Time of last disposal site inspection: _____

Location where specimen recovered _____

Weather conditions _____

Water temp (at dredge site) : Surface _____ Bottom (if known) _____

Species ID: __

Fill out “Sturgeon Data Collection Form” and Return to NMFS within 24 hours via email (incidental.take@noaa.gov) or fax (978-281-9394)

Comments/other (include justification on how species was identified)

Inspector/Oberver's Name _____

Signature _____

STURGEON DATA COLLECTION FORM

For use in documenting interactions with listed sturgeon resulting from Federal actions that have undergone sec 7 consultation

REPORTER'S CONTACT INFORMATION Name: First _____ Last _____ Agency Affiliation _____ Email _____ Address _____ Area code/Phone number _____	UNIQUE IDENTIFIER (Assigned by NMFS) DATE REPORTED: Month <input type="text"/> <input type="text"/> Day <input type="text"/> <input type="text"/> Year 20 <input type="text"/> <input type="text"/> DATE EXAMINED: Month <input type="text"/> <input type="text"/> Day <input type="text"/> <input type="text"/> Year 20 <input type="text"/> <input type="text"/>
--	--

SPECIES: (check one) <input type="checkbox"/> shortnose sturgeon <input type="checkbox"/> Atlantic sturgeon <input type="checkbox"/> Unidentified <i>Acipenser</i> species <i>Check "Unidentified" if uncertain .</i> See reverse side of this form for aid in identification.	LOCATION FOUND: <input type="checkbox"/> Offshore (Atlantic or Gulf beach) <input type="checkbox"/> 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) <input type="checkbox"/> 1 = Fresh dead <input type="checkbox"/> 2 = Moderately decomposed <input type="checkbox"/> 3 = Severely decomposed <input type="checkbox"/> 4 = Dried carcass <input type="checkbox"/> 5 = Skeletal, scutes & cartilage	SEX: <input type="checkbox"/> Undetermined <input type="checkbox"/> Female <input type="checkbox"/> Male How was sex determined? <input type="checkbox"/> Necropsy <input type="checkbox"/> Eggs/milt present when pressed <input type="checkbox"/> Borescope	MEASUREMENTS: Circle unit Fork length _____ cm / in Total length _____ cm / in Length <input type="checkbox"/> actual <input type="checkbox"/> estimate Mouth width (inside lips, see reverse side) _____ cm / in Interorbital width (see reverse side) _____ cm / in Weight <input type="checkbox"/> actual <input type="checkbox"/> estimate _____ kg / lb
--	--	---

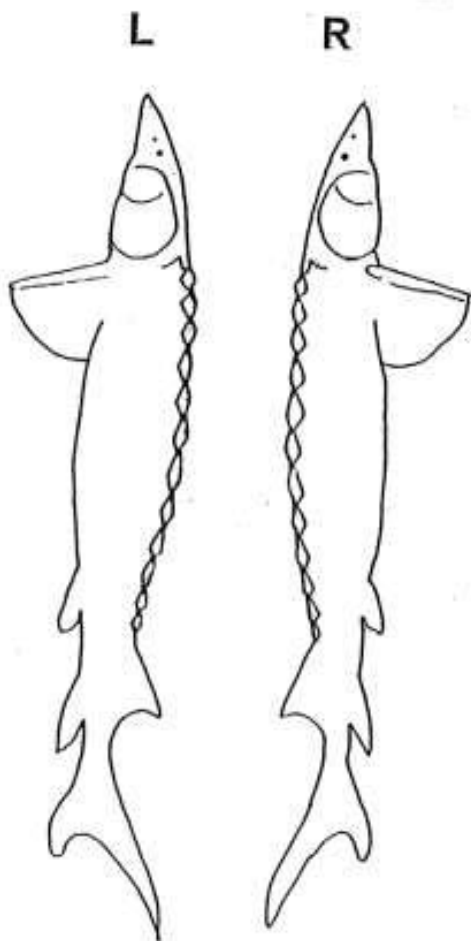
TAGS PRESENT? Examined for external tags including fin clips? <input type="checkbox"/> Yes <input type="checkbox"/> No Scanned for PIT tags? <input type="checkbox"/> Yes <input type="checkbox"/> No		
Tag # _____ _____	Tag Type _____ _____	Location of tag on carcass _____ _____

CARCASS DISPOSITION: (check one or more) <input type="checkbox"/> 1 = Left where found <input type="checkbox"/> 2 = Buried <input type="checkbox"/> 3 = Collected for necropsy/salvage <input type="checkbox"/> 4 = Frozen for later examination <input type="checkbox"/> 5 = Other (describe) _____	Carcass Necropsied? <input type="checkbox"/> Yes <input type="checkbox"/> No Date Necropsied: _____ Necropsy Lead: _____ _____	PHOTODOCUMENTATION: Photos/video taken? <input type="checkbox"/> Yes <input type="checkbox"/> No Disposition of Photos/Video: _____ _____ _____
--	---	--

SAMPLES COLLECTED? <input type="checkbox"/> Yes <input type="checkbox"/> No		
Sample _____ _____ _____	How preserved _____ _____ _____	Disposition (person, affiliation, use) _____ _____ _____

Comments:

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



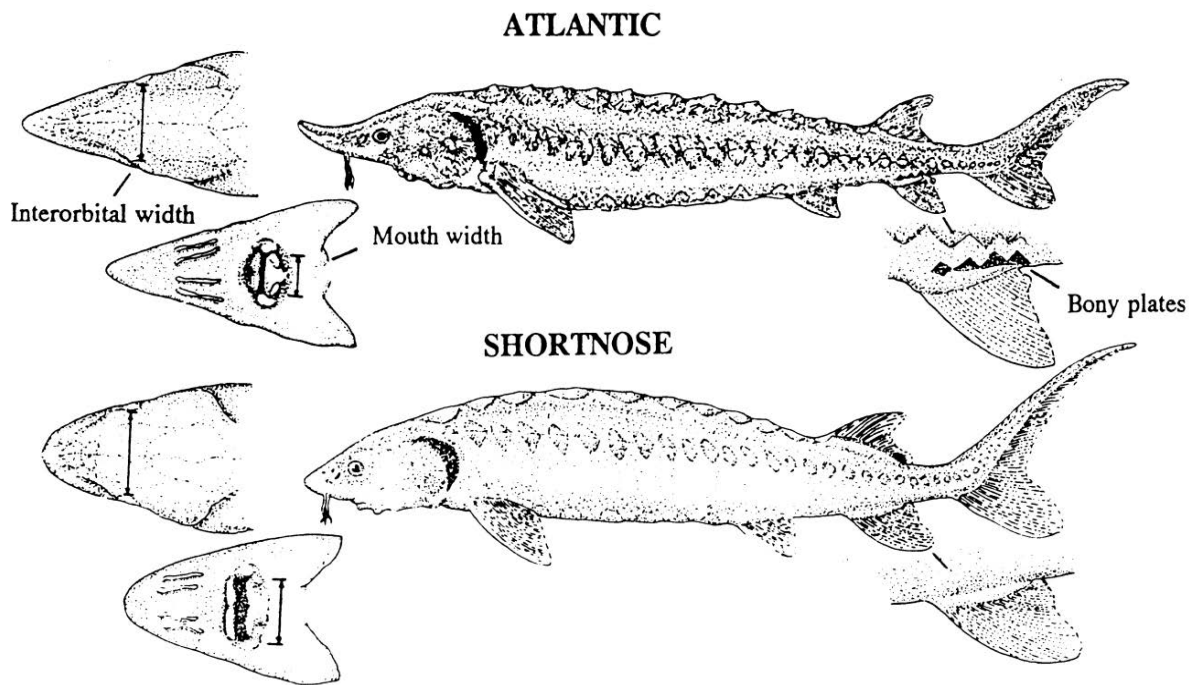
Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.). **Please note if no wounds / abnormalities are found.**

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

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (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.

Characteristic	Atlantic Sturgeon, <i>Acipenser oxyrinchus</i>	Shortnose Sturgeon, <i>Acipenser brevirostrum</i>
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth bony interorbital width	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 anal fin.	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 marine existence	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004



APPENDIX E

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:

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

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

Certification, Identification and Chain of Custody Form for Submitting Sturgeon Genetic Tissue Samples.^{1 2}

(A) CERTIFICATION OF SPECIES (Collector)

I, , hereby certify that I have positively identified the fish or fishes sampled in this shipment as: shortnose sturgeon; Atlantic sturgeon; other unknown based on my knowledge and experience as a Position Job Title.

Signature: Date Identified:
 Address:
 Phone Number:

(B) SAMPLE IDENTIFICATION

Species Identification: shortnose sturgeon; Atlantic sturgeon; unknown
 Unique ID No: ; Tissue Type: ; Preservative:
 Location: (River: ; River-km: ; Lat/Long:
 River Location Description:
 Total Length (TL) of Specimen (mm): Weight of Specimen (g): ; Sex (if known)

Specific comments on take:

Check here if multiple samples are submitted and use *Field Collection Report* (Appendix 3b) with the data fields listed in this section.

(C) EVIDENCE OF CHAIN OF CUSTODY

1.	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Release Signature	NMFS Permit No.	Method of Transfer
	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Receipt Signature	NMFS Permit No.	Date
2.	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Release Signature	NMFS Permit No.	Method of Transfer
	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Receipt Signature	NMFS Permit No.	Date
3.	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Release Signature	NMFS Permit No.	Method of Transfer
	<input type="text"/>	<input type="text"/>	<input type="text"/>
	Receipt Signature	NMFS Permit No.	Date

¹ Instructions on next page.

² If multiple samples are shipped, attach summary sheet in Appendix 3b.

Instructions: Collecting, Certifying, Identifying & Shipping Tissue Samples Collected from Sturgeon.

1. **Species Certification:**

For each shipment a “*Certification of Species Identification*” (Section A) must be provided. This form documents the collector has identified the fish or fishes sampled in the shipment as either a shortnose or Atlantic sturgeon. If there is any doubt about the identity of a sample, then mark unknown and include comments on the take.

2. **Sample Identification:**

Assign a unique number identifying each individual fish captured and subsequently sampled. This number must be recorded in Section B and on the collection vial for each sample taken. Record tissue type; preservative used; date of capture; location of capture (river & description, lat/long, river km, and nearest city); length of specimen; weight; and sex, if known. Check the box provided if you are submitting multiple samples, and provide a hard-copy and/or email a copy of the sample spreadsheet with information for each of the data fields listed above.

3. **Tissue Sampling Instructions:**

a. Cleanliness of Samples: Cross contamination should be avoided. For each fish, use a clean cutting tool, syringe, etc. for collecting and handling samples.

- b. Preserving & Packaging Samples:**
- i. Label vial with fish’s unique ID number.
 - ii. Place a 1-2 cm² section of pelvic fin clip in vial with preservative (95% absolute ETOH (un-denatured), recommended).
 - iii. Seal individual vials or containers with leak proof positive measure (e.g., tape).
 - iv. Package vials and absorbent within a double sealed container (e.g., zip lock baggie).
 - v. Label air package properly identifying ETOH warning label (**See Appendix 3c**).

c. Shipping Instructions:

When shipping samples, place separately Appendix 3a, 3b and 3c (Sample ID and Chain of Custody Forms and Shipping Training Form) in container and seal the shipping box to maintain the chain of custody. (Note: A copy of the ESA permit authorizing the collection of the sample(s) must also accompany the sample(s).)

Important Notice: You must be certified before shipping tissue samples preserved with 95% ETOH in “excepted quantities” (A Class 3 Hazardous Material Due to Flammable Nature). See Appendix 3c: “NMFS Guidelines for Air-Shipments of Excepted Quantities of Ethanol Solutions” to comply with the DOT/IATA federal regulations.

4. **Chain of Custody Instructions:**

The “*Chain of Custody*” (Section C) should be maintained for each shipment of tissue samples and must accompany the sample(s) at all times. To maintain the chain of custody, when sample(s) are transferred, the sample(s) and the documentation should be packaged and sealed together to ensure that no tampering has occurred. All subsequent handlers breaking the seal must also sign and document the chain of custody section.

5. **Contact Information:**

A. NMFS, Office of Protected Resources:

- i. **Primary Contact: (Northeast)** Shortnose Sturgeon Recovery Coordinator (Jessica Pruden, jessica.pruden@noaa.gov, 978/282-8482); Atlantic Sturgeon Recovery Coordinator (Lynn Lankshear, lynn.lankshear@noaa.gov, 978/282-8473)
- ii. **Primary Contact: (Southeast)** Shortnose Sturgeon Recovery Coordinator (Stephania Bolden stephania.bolden@noaa.gov, 727/824-5312); Atlantic Sturgeon Recovery Coordinator (Kelly Shotts, kelly.shotts@noaa.gov, 727/551-5603)
- i. **Secondary Contact:** Malcolm Mohead (malcolm.mohead@noaa.gov) Phone: 301/713-2289
- ii. **Secondary Contact:** Colette Cairns (colette.cairns@noaa.gov) Phone: 301/713-2289

B. NOS Archive:

- i. **Primary Contact:** Julie Carter (julie.carter@noaa.gov) Phone: 843/762-8547

NMFS Guidelines for Air-Shipment of "Excepted Quantities" of Ethanol Solutions

These guidelines have been adapted with permission from the University of New Hampshire-Office of Environmental Health & Safety; our appreciation is to Andy Glode for providing reference materials upon which this guide was created.

The U.S. Department of Transportation (DOT: 49 CFR 173.4) and the International Air Transport Association (IATA: 2007 Dangerous Goods Regulations, Sec. 2.7) regulate shipments of ethanol (ETOH) in *excepted quantities*. As a result, specific procedures must be followed as well as certifying proper training of individuals prior to packaging and shipping specimens preserved in ETOH. These guidelines will inform proper shipping and also satisfy certifying requirements. Failure to meet such requirements could result in regulatory fines and/or imprisonment.

Therefore, prior to submitting ETOH preserved samples and appropriate documentation (e.g., a FedEx Airbill) to a carrier, please read, initial and sign this document, affirming you have understood the requirements as outlined. Please include this document in the shipping package and retain a copy for your records.

- 1) Packages and documents submitted to a carrier must not contain any materials other than those described in this document (*i.e.* containers holding ethanol-preserved specimens and related absorbent and packaging materials). Also, laboratory or sampling equipment, *unrelated documents*, or other goods must be packaged and shipped in separate boxes. (Note: ETOH solutions are not permitted to be transported in checked baggage, carry-on baggage, or airmail.) I understand (____)

- 2) Please read the manufacturer's Material Safety Data Sheet (MSDS) for ETOH recognizing ETOH (55 - 100%) is classed as hazardous flammable material (NFPA Rating = 3). Note also, its vapor is capable of traveling a considerable distance to an ignition source causing "flashback." Properly packaging and labeling shipments of ethanol solutions will minimize the chance of leakage, and would also communicate the potential hazard to transport workers in the event of a leak. I understand (____)
 - a) **Quantity Limits:** Small quantities (inner container less than 30 ml, with a maximum net quantity of 500 ml for the entire package) of ETOH can be shipped with "Excepted Quantities" labels without completion of a Dangerous Goods Declaration. (e.g., If shipping vials having a maximum volume of 10 ml each, you may put up to 50 vials in one box.) I understand (____)

 - b) **Package Components:**
 - i. **Inner (primary) packaging (e.g., vial, tube, jar, etc.):** Do not completely fill inner packaging; allow 10% head-space for liquid expansion. Liquids must not completely fill inner packaging at a temperature of 55°C (130°F). Closures of inner packaging (e.g., vials with tops) must be held securely in place with tape or other positive means. I understand (____)

 - ii. **Intermediate (secondary) packaging (e.g. Ziplock or other plastic bag):** Place inner container(s) (e.g., vials with ETOH) into a high-quality plastic bag. Then add an absorbent material capable of absorbing any spillage without reacting with the ethanol. Seal the first bag tightly and then tape the locking seals. Next, seal the inner bag within a second bag for added safety. I understand (____)

 - iii. **Outer packaging (e.g., cardboard box):** Ethanol solutions may not be shipped in envelopes, Tyvek® sleeves, or other non-rigid mailers. The dimensions of the outer box must be at least 100 mm (~4 inches) on two sides. Any space between the inner packing containers placed in the outer packaging should be eliminated with additional filler. I understand (____)

 - c) **Package Labels:**
 - i. **Dangerous Goods in Excepted Quantities Label (Figure 1):** The label must display a "3" as the ethanol hazard class number using a black marker. You may obtain self-adhesive labels from NMFS, or else, order online. I understand (____)

 - ii. **Name and Address:** The outer container must display the name and address of the shipper and consignee. When re- using shipping boxes, completely remove or black out all unnecessary labels or marks. I understand (____)

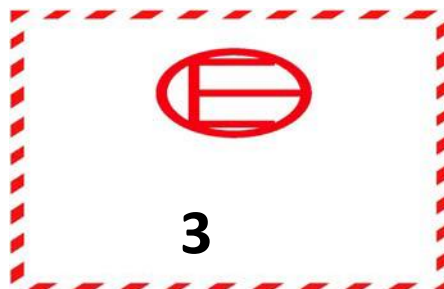


Figure 1. Dangerous Goods in Excepted Quantities label

Package Tests:

A representative example of packaging used for excepted quantities of ethanol solutions must pass a drop test and compressive load test without any breakage or leakage of any inner packaging and without any significant reduction in package effectiveness. Perform the following tests on a representative example of your packaging and keep a record of the results.

ii. **Drop Test:** Drop a representative package from a height of 1.8 m (5.9 feet) directly onto a solid unyielding surface:

- | | |
|--|---------------------|
| | Test Results |
| a. One drop flat on the base; One | (_____) |
| b. drop flat on top; | (_____) |
| c. One drop flat on the longest side; | (_____) |
| d. One drop flat on the shortest side; and | (_____) |
| e. One drop on a corner. | (_____) |

iii. **Compressive Load Test:** Apply a force to the top surface of a representative package for a duration of 24 hours, equivalent to the total weight of identical packages if stacked to a height of 3 meters. (_____)

d) Package Documentation:

Proper documentation is required for all shipments of hazardous materials. Incorrect documentation is the most common cause for package refusal. If using documentation for couriers other than FedEx, UPS and DHL, please contact NMFS for assistance.

i. **FedEx:** For domestic shipments with FedEx Express, fill out the standard US Airbill. Fill out the form completely including the following information:

- a. In Section 6, Special Handling, check the box “Yes, Shipper’s Declaration not required.”
- b. On the top of the form above the FedEx tracking number, include the statement, “**Dangerous Goods in Excepted Quantities**” See example in **Figure 2**. I understand (____)

ii. **DHL:** The “*Nature and Quantity of Goods*” box of the air waybill must include “**Dangerous Goods in Excepted Quantities.**” I understand (____)

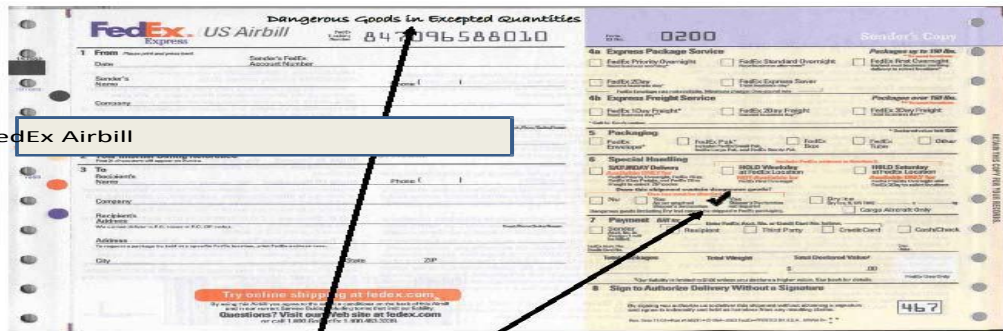


Figure 2. Example of FedEx Airbill

include this statement and check this box.

By signing this document, I affirm I understand the hazards associated with ethanol and the shipping requirements for ethanol solutions, as outlined in this guide. I also understand I am required to include a copy of this document in the package and that it should be appended to an ESA permit (if listed samples are shipped).

Print Name:		Signature:	
Employer:		Employer Address:	
Date:		Phone:	

APPENDIX F

Protocol for Collecting Tissue from Sea Turtles for Genetic Analysis

Materials for Collecting Genetic Tissue Samples

- <surgical gloves
- <alcohol swabs
- <betadine swabs
- <sterile disposable biopsy punches
- <sterile disposable scalpels
- <permanent marker to externally label the vials
- <scotch tape to protect external labels on the vials
- <pencil to write on internal waterproof label
- <waterproof label, 1/4" x 4"
- <screw-cap vial of saturated NaCl with 20% DMSO*, wrapped in parafilm
- <piece of parafilm to wrap the cap of the vial after sample is taken
- <vial storage box

* The 20% DMSO buffer within the vials is nontoxic and nonflammable. Handling the buffer without gloves may result in exposure to DMSO. This substance soaks into skin very rapidly and is commonly used to alleviate muscle aches. DMSO will produce a garlic/oyster taste in the mouth along with breath odor. The protocol requires that you wear gloves each time you collect a sample and handle the buffer vials. **DO NOT** store the buffer where it will experience extreme heat. The buffer must be stored at room temperature or cooler, such as in a refrigerator.

Please collect two small pieces of muscle tissue from all live, comatose, and dead stranded loggerhead, green, leatherback, and hybrid sea turtles (and any hawksbills, although this would be a rare incident). A muscle sample can be obtained no matter what stage of decomposition a carcass is in. Please utilize the equipment in these kits for genetic sampling of **turtles only** and contact the NMFS sea turtle stranding coordinator when you need additional biopsy supplies.

Sampling Protocol for Dead Turtles

1. Put on a pair of surgical gloves. The best place to obtain the muscle sample is on the ventral side where the front flippers insert near the plastron. It is not necessary to cut very deeply to get muscle tissue.
2. Using a new (sterile and disposable) scalpel cut out two pieces of muscle of a size that will fit in the vial.
3. Transfer both samples directly from the scalpel to a single vial of 20% DMSO saturated with salt.
4. Use the pencil to write the stranding ID, date, species ID and SCL on the waterproof label and place it in the vial with the samples.

5. Label the outside of the vial using the permanent marker with stranding ID, date, species ID and SCL.
6. Apply a piece of clear scotch tape over what you have written on the outside of the vial to protect the label from being erased or smeared.
7. Wrap parafilm around the cap of the vial by stretching as you wrap.
8. Place the vial in the vial storage box.
9. Complete the Sea Turtle Biopsy Sample Collection Log.
10. Attach a copy of the STSSN form to the Collection Log - be sure to indicate on the STSSN form that a genetic sample was taken.
11. Dispose of the used scalpel and gloves. It is very important to use a new scalpel for each animal to avoid cross contamination.

**At the end of the calendar year submit all genetic samples to:
Sea Turtle Stranding Coordinator
NMFS Protected Resources
Division 55 Great Republic Drive
Gloucester, MA 01930
(978)281-9328**