NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

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

Activity Considered: Deepening of the Delaware River Federal Navigation Channel (Reinitiation)
F/NER/2011/00754
GARFO-2011-00010

Conducted by: National Marine Fisheries Service
Northeast Region

Date Issued: 7/11/12

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 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) dated April 2009; a supplement to the EA dated September 2011; NMFS October 25, 1996 Opinion on dredging in the Philadelphia District of the Army Corps of Engineers (ACOE); 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 Opinion 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 Northeast Regional 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 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 deep[1] 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, 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 the ACOE 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

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[1] All depths refer to mean low water.

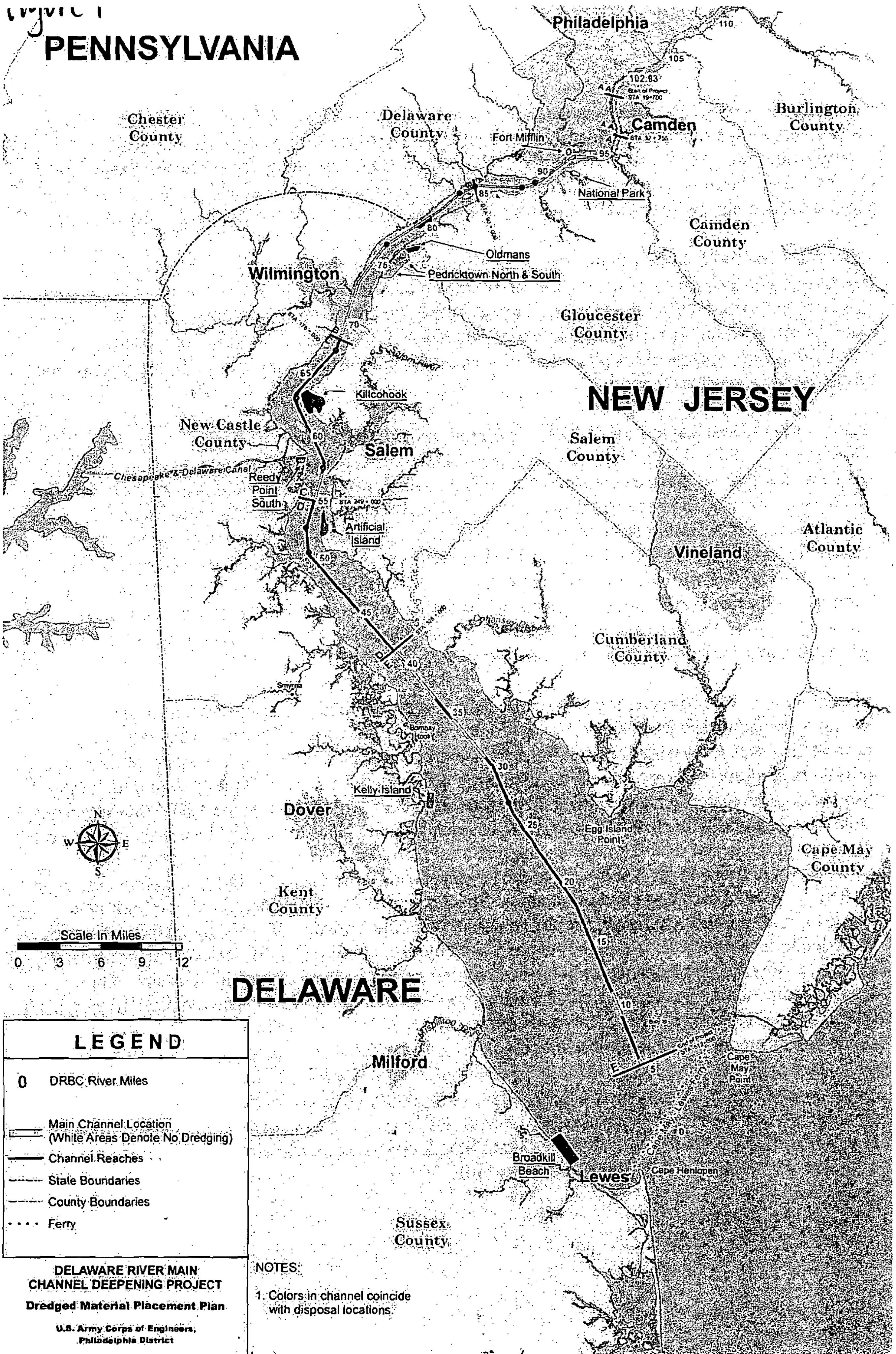
channel requires annual maintenance dredging in the amount of approximately 3,455,000 cubic yards. Of this amount, the majority of material is removed from the Marcus Hook (44%), Deepwater Point (18%) and New Castle (23%) ranges. The remaining 15 percent of material is spread throughout the other 37 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 ACOE Maintenance of the Existing Channel

In September 1986, the 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 ACOE 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 ACOE 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 ACOE in the Philadelphia District. The Opinion concluded that the 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.


PENNSYLVANIA
Philadelphia
Chester County
Delaware County
Fort Mifflin
Camden
Burlington County
National Park
Camden County
Oldmans
Pedricktown North & South
Wilmington
Gloucester County
Salem River
Killcohook
NEW JERSEY
New Castle County
Salem
Salem County
Chesapeake & Delaware Canal
Reedy Point South
Artificial Island
Vineland
Atlantic County
Cumberland County
Smyrna
Bombay Hook
Kelly Island
Dover
Egg Island Point
Cape May County
Kent County
Scale In Miles
0 3 6 9 12
DELAWARE
Milford
Cape May Point
Cape May-Lewes Ferry
Broadkill Beach
Lewes
Cape Henlopen
Sussex County
LEGEND
0 DRBC River Miles
Main Channel Location (White Areas Denote No Dredging)
Channel Reaches
State Boundaries
County Boundaries
Ferry
DELAWARE RIVER MAIN CHANNEL DEEPENING PROJECT
Dredged Material Placement Plan
U.S. Army Corps of Engineers, Philadelphia District
NOTES:
1. Colors in channel coincide with disposal locations.

DELAWARE RIVER MAIN CHANNEL DEEPENING

PROJECT SCHEDULE - FEBRUARY 2012

Timeline columns: 2011 (A S O N D) · FISCAL YEAR 12 · 2012 (J F M A M J J A S O N D) · FISCAL YEAR 13 · 2013 (J F M A M J J A S O N D) · FISCAL YEAR 14 · 2014 (J F M A M J J A S O N D) · FISCAL YEAR 15 · 2015 (J F M A M J J A S O N D) · FISCAL YEAR 16 · 2016 (J F M A M J J A S O N D) · FISCAL YEAR 17 · 2017 (J F M A M J J A S O N D)

DREDGING CONTRACTS	Duration (Mo)	Estimated Quantity (cy)	Dredging Window & Type
Contract No. 2			hyd
Reach B			
155+000 to 176+000 - Pedricktown South	1.95	1,051,564	HYD
Contract Total		1,051,564	
Contract No. 3			hyd
Reach AA			
19+700 to 32+756 - National Park	2.88	994,000	HYD
Reach A			
32+756 to 90+000 - Pedricktown North	6.10	1,666,600	HOP
Reach B			
090+000 to 096+000 - Pedricktown North	0.62	127,867	HYD
Contract Total		2,788,467	
			hop
Contract No. 4			bla
Rock Removal			
Blasting	3.17		BLA
Dredging - Fort Mifflin	3.17	77,000	MEC
Contract Total		77,000	
			mec
Contract No. 5			hop
Reach E			
461+300 to 512+000 - Broadkill Beach	3.00	1,598,700	HOP
Contract Total		1,598,700	
Contract No. 6			hop
Reach E			
351+300 to 461+300 - Kelly Island	4.50	2,483,000	HOP
Contract Total		2,483,000	
Contract No. 7			hop
Reach D			HOP
249+000 to 270+000 - Reedy Point South	1.13	396,300	
270+000 to 324+000 - Artificial Island	4.63	1,654,800	
Contract Total		2,051,100	
Contract No. 8			hyd
Reach B			
Marcus Hook Anchorage - Oldmans	0.89	1,671,400	HYD
096+000 to 124+000 - Pedricktown North	2.89	922,833	HYD
124+000 to 137+000 - Pedricktown South	0.45	499,300	HYD
137+000 to 155+000 - Pedricktown South	0.73	391,936	HYD
Contract Total		3,485,469	
Total Channel	41.9	16,038,100	
Berth Deepenings			
Berth Deepenings Drill/Blast			
Berth Deepenings Clamshell			
Berth Deepenings CSD Rehandling WP			
Total Berth Deepenings		460,437	

Legend:

- HOP - HOPPER DREDGE
- HYD - CUTTER SUCTION DREDGE
- LANDSIDE CONSTRUCTION
- MEC - CLAMSHELL DREDGE
- BLA - DRILLBOAT (BLASTING)
- DREDGING WINDOW

Revised February 2012

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 ACOE 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 ACOE 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 (District) website on December 18, 2008, announcing that the 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 NMFS' jurisdiction. Following the exceedence 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 ACOE requesting the initiation of consultation regarding the effects of the proposed deepening on listed species. Supplemental information was provided by the ACOE on February 9, 2009. Also sent in February 2009 was a letter from the ACOE 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 ACOE planned maintenance dredging. On March 12, 2009, a revised project schedule was provided to us by the ACOE and on April 3, 2009 a final Environmental Assessment (EA) was distributed by the ACOE. Consultation was initiated on February 9, 2009.

A Biological Opinion was signed by NMFS 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 NMFS listed species 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 ACOE. In March 2011, ACOE 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 ACOE published a draft supplemental EA. In an August 15, 2011, letter we provide the ACOE with technical assistance regarding upcoming dredging of Reach B. The ACOE 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 ACOE 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 April 6, 2012, NMFS 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 ACOE on June 22, 2012. Comments were received on July 2 and July 3, 2012. These comments have been addressed as appropriate. By issuing this Opinion, we withdraw the Opinion dated July 17, 2009.

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, therefore, includes the entirety of the Philadelphia to the Sea Federal navigation channel, including the authorized anchorages and bends to be widened. Additionally, the action area includes the beneficial use disposal areas at Kelly Island and Broadkill 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.

3.1.1 Physical Characteristics of the Action Area

The Delaware River Estuary is 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 11 miles at the Capes; to 27 miles 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 two miles 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 (RM 67 (rkm 108)), 20 miles 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 5 miles (8 km) from the theoretical line between Cape Henlopen and Cape May Point.

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

Table 1. Description of Delaware River Channel Reaches

The existing channel is maintained at a depth of 40 feet deep at mean low water. Only portions of the channel that are currently between 40 feet and 45 feet at mean low water 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 would be dredged; this is 1.2 percent of the total estuary surface area and 55 percent of the existing channel. 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); 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). 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:

1. **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. **2.** MIAH MAULL-CROSS LEDGE: 200 foot width increase at the apex of the west side of the bend;
3. **3.** 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);
4. **4.** 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);
5. **5.** 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);
6. **6.** 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);
7. **7.** 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);
8. **8.** 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);
9. **9.** 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);
10. **10.** 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);
11. **11.** 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);

12. 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 Kelly Island and Broadkill Beach.

3.2.1 Initial Dredging Cycle

For the initial deepening, approximately 16 million cubic yards (cy) of material would 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 1). In addition, approximately 77,000 cubic yards of rock would be removed in the vicinity of Marcus Hook, Pennsylvania and placed in the Fort Mifflin confined disposal facility in Philadelphia. Blasting would be used in this area, followed by removal of rocky material with a mechanical dredge.

Initial construction began in March 2010. Initial construction is currently scheduled to continue through January 2017. To date, the first and the second phase of dredging has been completed (Reach C and a portion of Reach B). 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 May 2012)

Channel Reach	River Mile	Duration (Months)	Volume (CY)	Type of Dredge	Scheduled Dates[2]
Contract 3 – Reach A	97-84.42	6.1	1,666,600	Cutterhead, hopper or mechanical	August 2012 – February 2013
Contract 4 - Reach D	57.71-41.57	5.78	2,051,100	Cutterhead or hopper	December 2012 – June 2013
Contract 5 - Reach E (Broadkill Beach)	15.6	3.00	1,598,700	hopper (2)	September – December 2013
Contract 6 – Reach AA	99.3-97.1	2.88	994,000	Cutterhead, hopper or mechanical	August – November 2014
Contact 7 – Rock	76.4 -		77,000	Mechanical	December 2014 –

[2] Schedule is subject to change based on available funding.

Removal: Blasting and Clean Up Dredging	84.6				February 2015
Contract 8 - Reach E (Kelly Island)	30.8-36.4	4.50	2,483,000	hopper (2)	April - August 2015
Contract 9 - Reach B	85-67	0.89	3,485,469	cutterhead	August 2016 – January 2017

Reach E is considered to be in Delaware Bay. Figure 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 the ACOE. The ACOE 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. Time periods shaded grey are the recommended periods for hopper dredging, cutterhead pipeline dredging, bucket dredging, sand placement and blasting.

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 (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 placement site where dredged material is disposed of. A hopper dredge is likely to be used in reaches A, D and E but could also be used in Reach AA.

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. The ACOE has also indicated that a bucket dredge may be used in Reach AA due to the presence of rocky substrate.

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 reaches AA, A, B, C, and D.

Rock Blasting
Approximately 77,000 cubic yards of bedrock from 18 acres in reach B near Marcus Hook, PA (RM 76.4 to 84.6) would 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 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 approximately 2 to 6 blasts conducted per day. The broken and pulverized rock along with overlying sands and silts will be removed by a mechanical dredge. Blasting is scheduled to occur in the winter of 2014-2015.

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

- 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, for each blast, the ACOE 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 at 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. The ACOE 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. The ACOE is also considering the use of trawlers to relocate fish away from the blasting site.

3.3 Dredged Material Disposal

As stated above, it is anticipated that approximately 16 million y^3 of material will be removed from the channel over a five year period during initial construction. All material removed from reaches AA, A, B, C, and D, regardless of dredge type, will be disposed of at an upland location. Material removed from reach E will be used at a beneficial use site (see below). Approximately 4 million y^3 of suitable material removed from the channel in reach E will be used for wetland restoration or beach nourishment. Descriptions of the proposed beneficial use sites are provided below.

3.3.1 Kelly Island (Delaware)

As stated by the ACOE, the main purposes of the Kelly Island wetland restoration project are to restore intertidal wetlands using dredged sediment from the deepening of the Delaware River navigation channel, stem erosion of the Kelly Island shoreline estimated at 20 feet per year, provide extensive sandy beach for spawning horseshoe crabs, and provide continued protection to the entrance of the Mahon River.

The site will be constructed as an impoundment and remain as such until the sediments consolidate and vegetation becomes established. At that time, the State of Delaware will decide whether to open the site up to unregulated tidal inundation. The option to convert back to an impoundment will be maintained. Following construction, the site will be monitored to insure that the goals of the project are met and that no adverse impacts occur, particularly impacts to oyster beds.

Features of the project include:

- Sixty acres of wetlands where the substrate will consist of an estimated 55,000 cubic yards of silt and 645,000 cubic yards of sand.
- An offshore containment dike made of 1.7 million cubic yards of sand that will provide up to 5,000 linear feet of sandy beach. The crest of the dike will be at +10 ft MLW providing substantial spawning habitat for horseshoe crabs.
- A geotextile tube within the core of the offshore dike that provides overwash protection and contingency protection against breaching.
- Timber groins to limit sand transport along the beach.
- Option for water level control or free tidal exchange with the bay.

Construction of the sand dikes will begin at the south end gaining access to the site from the Mahon River channel. Once the dikes are constructed, the interior will be filled. Filling will take approximately 4 months. The total time to construct Kelly Island is 6 months with construction scheduled to occur between April and September.

Once the containment area/beach is constructed, fine-grained sediment will be placed first followed by placement of sand. The volume of sediment to be placed in the site will ultimately achieve a surface elevation of +5 feet MLW which is at the upper part of the tidal range. After construction, and possibly for several years, the water levels in the site will be controlled. The offshore dike will have a crest elevation of +10 feet MLW. This elevation is coincident with the water level for a return interval between 10 and 25 years. It is only during rare events that this sand dike will be overtopped. As noted in the BA, the dike is expected to provide up to 5,000 linear feet of spawning habitat for horseshoe crabs.

The crest width of the dike will be 200 feet at its narrowest and 350 feet at its widest. The volume of sand in the cross section of the dike will be constant, i.e. 845 cubic yards per linear yard. Therefore, the crest width of the dike in shallow water will be greater than in deeper water. The total volume of sand required for the offshore dike is 1.7 million cubic yards (which includes a quantity sufficient to offset an estimated one foot of settlement). The offshore slope of the dike is estimated to be initially 1:20, and after the first year of "weathering" it should equilibrate to a milder 1:40 slope.

The southern end of the offshore dike will terminate on the island. The elevation of the crest of the dike will transition from +10 feet MLW to the +7 feet MLW (approximate) elevation of the existing marsh. The dike will extend onto the island far enough to prevent southerly waves at high water levels from damaging any portion of the interior of the project. The dike will also extend beyond its connection with the landward dike.

The northern end of the offshore dike will extend approximately 300 feet beyond Deepwater Point roughly parallel to the shoreline. The outlet works for the project will be placed at Deepwater Point, and so the offshore dike will protect that location. A geotextile tube will be placed within the offshore dike as a factor of safety against a breach in the dike due to an extreme event and overwash. The crest of the tube will be placed to a crest elevation of +7 feet MLW. The tube will then be buried under an additional three feet of sand bringing the crest of the dike up to elevation +10 feet MLW. The protection that the tube provides should allow time for maintenance or repair work to be planned and executed if a breach should develop due to overwash.

A landward dike will be constructed along the edge of the existing marsh with a crest elevation of +8 feet MLW. The dike crest width will be 20-30 feet. The dike will prevent dredged material from flowing across or settling in the existing marsh. The dike will be built-up by trucking sand from the larger offshore dike to the landward dike during construction. The dike will not be constructed by hydraulic placement of sand. The dike will be left in place after construction to impound the site. In the future, if the State of Delaware decides that the site should function with unregulated tidal exchange with the bay, the landward dike may be removed. However, if the capability to impound the site at some future date is necessary, then the landward dike should not be removed.

Sheetpile groins made of either timber or vinyl will be placed along the perimeter of the offshore dike to help limit longshore transport. Although the cross-section of the dike is designed to sustain sediment losses for many years without losing any of its function, groins will increase the longevity of the project, reduce potential maintenance, and add a factor of safety against the risk that sand will be transported south along the project into the Mahon River entrance. The groins will extend seaward from the crest of the dike about 240 feet. They will extend landward from the crest of the dike about 50 feet. Therefore, their total length is 290 feet. The groins will follow the initial profile of the dike having a 1:20 slope from the crest of the berm to MLW. The crests of the groins will be nominally about 2 feet above the sand berm initial cross-section. The groins will be spaced about 750 feet apart. At both ends of the project, terminal timber sheet-pile groins will be constructed that are 450 feet long. The groins will be constructed after the sand berm is constructed.

The outlet works for the marsh will be placed through a cross-shore sand dike at the north end of the project extending from the tip of Deepwater Point to the offshore dike. The elevation of the crest of the cross-shore dike will be +8 feet MLW which is sufficient to prevent even the annual highest high tide from overtopping the dike. This elevation also provides sufficient freeboard so that water levels in the site can be held high if needed. The cross-shore dike does not need additional elevation to prevent wave overtopping because it is protected from waves by the offshore dike. A geotextile tube like the one described for the offshore sand dike will be placed in the core of the cross-shore dike. The flows through the outlet works during dredging depend mainly on the depth of water above the weir crests.

The outlet works will have outflow pipes that pass through the core of the cross-shore dike. The cross-section of the cross-shore dike will be held to a minimum to minimize the length of outlet pipe required. The actual crest width of the dike will depend on the stability of the foundation upon which the dike is built. The dike will be filled until a stable cross-section is achieved. The dike will be constructed by moving sand from the offshore dike with heavy equipment so that steeper side slopes can be achieved which will minimize the dike cross-section.

The outlet works provided at the north end of the project will control release of water during dredging. Several drop inlets are planned. The capacity of the outlet works will depend on the size of the dredge pump and discharge line, the frequency of hopper discharges (cycle time), and water control requirements for post-construction marsh management. But the potential to release water at a rate as high as 75-100 cfs may be required.

An outlet works at the southern end of the project will not be necessary for dredging purposes. However, tidal connection to the southern end of the site may be desired after the marsh develops and natural flow patterns emerge. Any additional tidal connection will be achieved, for example, through small tidal guts through the existing marsh to the Mahon River and not through the offshore dike.

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 will be executed as Contract 5 and scheduled for September – December 2013. Beach grading will be done by bulldozer and is expected to take six months to complete during the fall and winter.

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 10 years of annual maintenance dredging (through 2027).

4.0 STATUS OF LISTED SPECIES IN THE ACTION AREA

Several species listed under NMFS' 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 listed whales are known to occur in the action area. As such, no whale species will be further discussed in this Opinion.

NMFS has determined that the action being considered in this biological opinion may affect the following endangered or threatened species under NMFS' jurisdiction:

Sea Turtles

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

Fish

Shortnose sturgeon (*Acipenser brevirostrum*)	Endangered
Gulf of Maine DPS of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)	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 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

[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.

and brought into rehabilitation centers; of these, 456 were visibly oiled (these and the 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, NMFS and FWS determined that loggerhead sea turtles should not be delisted or reclassified as endangered. 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 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, NMFS and FWS established a Loggerhead Biological Review Team (BRT) 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, NMFS and USFWS published a proposed rule (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, NMFS and USFWS issued a final rule (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. NMFS and USFWS 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. NMFS has 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 ≥11°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 3 in this Opinion) highlights the key life history parameters for loggerheads nesting in the United States.

Table 3. 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]
Internesting 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); Bjorndal *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 S*argassum* 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, NMFS and USFWS (2007c) 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.

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 (Cliffton *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 (Kasparek *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 Achipelago, 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 Sites[4] distributed globally revealed a 48-67% decline in the number of mature females nesting annually over the last three generations[5] (Seminoff 2004). An evaluation of green sea turtle nesting sites was also conducted as part of the 5-year status review of the species (NMFS

[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

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).

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 its 5-year status review of the species, NMFS and USFWS (2007d) determined that the listing classification for green sea turtles should not be changed. 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 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, NMFS 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, NMFS published a positive 90-day finding on the petition and convened a critical habitat review team. On January 26, 2012, NMFS 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 Semaeostomeae, 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, Chryaora*, 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, NMFS 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. NMFS 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. NMFS 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 (42[6]), 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

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

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 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 8-9ºC. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse et al. 1987; Crowder et al. 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to

[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.

ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

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

At hatching, shortnose sturgeon are blackish-colored, 7-11mm long and resemble tadpoles (Buckley and Kynard 1981). In 9-12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15mm total length (TL; Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20mm TL. Dispersal rates differ at least regionally, laboratory studies on Connecticut River larvae indicated dispersal peaked 7-12 days after hatching in comparison to Savannah River larve 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). Though there is evidence from the Delaware River that sub-adults may overwinter in different areas than adults and no not form dense aggregations like adults (ERC Inc. 2007). Sub-adults feed indiscriminately, typical prey items found in stomach contents include aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Dadswell 1979, Carlson and Simpson 1987, Bain 1997).

In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware and Merrimack Rivers), spawning areas are located at the farthest upstream reach of the river (NMFS 1998). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures reach between 7-9.7ºC, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location and water temperature. Sturgeon spawn in upper, freshwater areas and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998).

Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during a four year telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell et al. 1984; NMFS 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 15º, and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell et al. 1984; Hall et al. 1991, Kieffer and Kynard 1996, NMFS 1998). For northern shortnose sturgeon, the temperature range for spawning is 6.5-18.0ºC (Kieffer and Kynard in press). Eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell et al. 1984). Between 8° 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 3ºC (Dadswell et al. 1984) and as high as 34ºC (Heidt and Gilbert 1978). However, temperatures above 28ºC are thought to adversely affect shortnose sturgeon. In the Altamaha River, temperatures of 28-30ºC 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 compromised of breeding subpopulations (NMFS 1998).

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

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

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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.

northern and other regional subdivisions), shortnose sturgeon appear to be discrete stocks, and low gene flow exists between the majority of populations.

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

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

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

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. Shortnose sturgeon are large, long lived fish species. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes vary across the species' range. From available estimates, the smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) in the south and Merrimack and Penobscot rivers in the north (~ several hundred to several thousand adults depending on population estimates used; M. Kieffer, United States Geological Survey, personal communication; Dionne 2010), while the largest populations are found in the Saint John (~18, 000; Dadswell 1979) and Hudson Rivers (~61,000; Bain et al. 1998). As indicated in Kynard 1996, adult abundance is less than the minimum estimated viable population abundance of 1000 adults for 5 of 11 surveyed northern populations and all natural southern populations. Kynard 1996 indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. Expected abundance in southern rivers is uncertain, but large rivers should likely have thousands of adults. The only river systems likely supporting populations of these sizes are the St John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species 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 semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs, DDE (an organochlorine pesticide) were detected in the "adverse affect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. Contaminant analysis conducted in 2003 on tissues from a shortnose sturgeon from the Kennebec River revealed the presence of fourteen metals, one semivolatile compound, one PCB Aroclor, Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in one or more of the tissue samples. Of these chemicals, cadmium and zinc were detected at concentrations above an adverse effect concentration reported for fish in the literature (ERC 2003). While no directed studies of chemical contamination in shortnose sturgeon have been undertaken, it is evident that the heavy industrialization of the rivers where shortnose sturgeon are found is likely adversely affecting this species.

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

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

Status and Distribution of Shortnose Sturgeon in the Delaware River

Shortnose sturgeon occur in the Delaware River from the lower bay upstream to at least Lambertville, New Jersey (river mile 148). Tagging studies by O'Herron et al. (1993) found that the most heavily used portion of the river appears to be between river mile 118 below Burlington Island and river mile 137 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. 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. 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 March[9], with spawning occurring through early May. 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 8-9ºC with most spawning occurring when water temperatures are between 10 and 18ºC. Until recently, actual spawning (i.e., fertilized eggs or larvae) had not been documented in this area; however, the concentrated use of the Scudders Falls region in the spring by large numbers of mature male and female shortnose sturgeon indicated that the area between Scudders Falls and the Trenton rapids (rkm223-214) is the major spawning area, though shortnose sturgeon eggs were collected upstream of Titusville, NJ (rkm 229) in spring 2008 (O'Herron et al. 1993; ERC 2009). The same area was identified as a likely spawning area based on the collection of two ripe females in the spring of 1965 (Hoff 1965). 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 18ºC, shortnose sturgeon move rapidly downstream to the Philadelphia area.

Shortnose sturgeon eggs generally hatch after approximately 9-12 days (Buckley and Kynard 1981).

[9] 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, mean daily 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 15ºC between April 15 (2006) and May 4 (2007). There is typically a three to four week period with mean daily temperatures between 8 and 15°C.

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).

No studies have been conducted on juveniles in the Delaware River. As shortnose sturgeon demonstrate nearly identical migration patterns in all rivers, it is likely that juveniles in the Delaware River exhibit similar migration patterns to sturgeon in other river systems. As such, it is likely that yearlings are concentrated in the upper Delaware River above Philadelphia.

As noted above, due to limited information on juvenile shortnose sturgeon, it is difficult to ascertain their distribution and nursery habitat (O'Herron 2000, pers. comm.). Sub-adults are typically described as age one or older and occupy similar spatio-temporal patterns and habitat-use as adults (Kynard 1997). In these systems, juveniles moved back and forth in the low salinity portion of the 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 (river mile 54) to the Schuylkill River (river mile 92) (O'Herron 2000, pers. comm.). 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. Juveniles 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). 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 river mile 127 and 134 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-November[10], adult sturgeon have returned to the overwintering grounds in the Roebling (rkm 199), Bordentown (rkm 207), or Trenton reaches (rkm 214). These patterns are generally supported by the movement of radio-tagged fish in the region between river mile 125 and river mile 148 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 December and March. Adult sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between river mile 118 and 131. The areas around Duck Island and Newbold Island seem to be regions of intense overwintering concentrations. However, unlike sturgeon in other river systems, shortnose sturgeon in the Delaware do not appear to remain as stationary during overwintering periods. Overwintering fish have been found to be generally active, appearing at the surface and even breaching through the skim ice (O'Herron 1993). Due to the relatively active nature of these fish, 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 1.24 river miles of the aggregation site (O'Herron and Able 1986). Investigations with video equipment by the ACOE in March 2005 (Versar 2006) documented two sturgeon of unknown 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 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. Preliminary tracking studies of juveniles indicate that the entire lower Delaware River from Philadelphia (rkm 161) to below Artificial Island (rkm 79) may be utilized as an overwintering area by juvenile shortnose sturgeon (ERC 2007). There is also evidence that unlike adults, juveniles do not form dense aggregations and instead are more dispersed in overwintering areas (ERC 2007).

Shortnose sturgeon appear to be strictly benthic feeders (Dadswell 1984). Adults eat mollusks, insects, crustaceans and small fish. Juveniles eat crustaceans and insects. While shortnose sturgeon forage on a variety of organisms, in the Delaware River, sturgeon primarily feed on the Asiatic river clam (*Corbicula manilensis*). *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

[10] 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).

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 on the trash racks of the Salem nuclear power plant in Salem, New Jersey at Artificial Island. The intakes for this plant are located in Delaware Bay. While the available information does not identify the area below Philadelphia as a concentration area for adult shortnose sturgeon, it is apparent that this species does occur in the lower Delaware River and upper Delaware Bay.

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 RM 78, approximately 20 miles 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 2.7 miles upstream of the project site, at RM 81), and one near the upstream end of the Cherry Island Flats (at RM 74; approximately 3.8 miles 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 fished 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 one each during the June, July and August sampling events. Two of the shortnose sturgeon were collected at RM 78 and one was taken at the downstream sampling station at RM 74. Total length ranged from 311-367mm. During the September – December sampling, one juvenile shortnose sturgeon was caught in September at RM 78 and one in November at the same location. One adult shortnose sturgeon was captured in October at RM 74. 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 (RM 74) 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 RM 93, Tinicum RM 86, Bellevue RM 73 and New Castle RM 58 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 fish tagged were adults tagged after collection in gill nets in the upper tidal Delaware River, between RM 126-132. 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 New Castle 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.

Information on the use of the river by juveniles is lacking and the information available is extremely limited (i.e., 5 captures). As evidenced by the Crown Landing study, juvenile shortnose sturgeon have been documented between RM 81-74 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. However, the April – August time frame is when flows in the Delaware River are highest and the time when the action area is likely to experience the low salinity levels preferred by juveniles (FERC 2005). Beginning in August, flows decrease and the salt wedge begins to move upstream, which may preclude juveniles from occurring in the action area. Based on this information, it is likely that juvenile shortnose sturgeon are present in the action area at least during the April – August time frame. The capture of juvenile shortnose sturgeon in the RM 81-74 range in November of 2005 suggests that if water conditions are appropriate, juveniles may also be present in this area through the fall. While it is possible, based on habitat characteristics, that this area of the river is used as an overwintering site for juveniles, there is currently no evidence to support this presumption.

In 2005, the ACOE 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 over wintering 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 two 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.

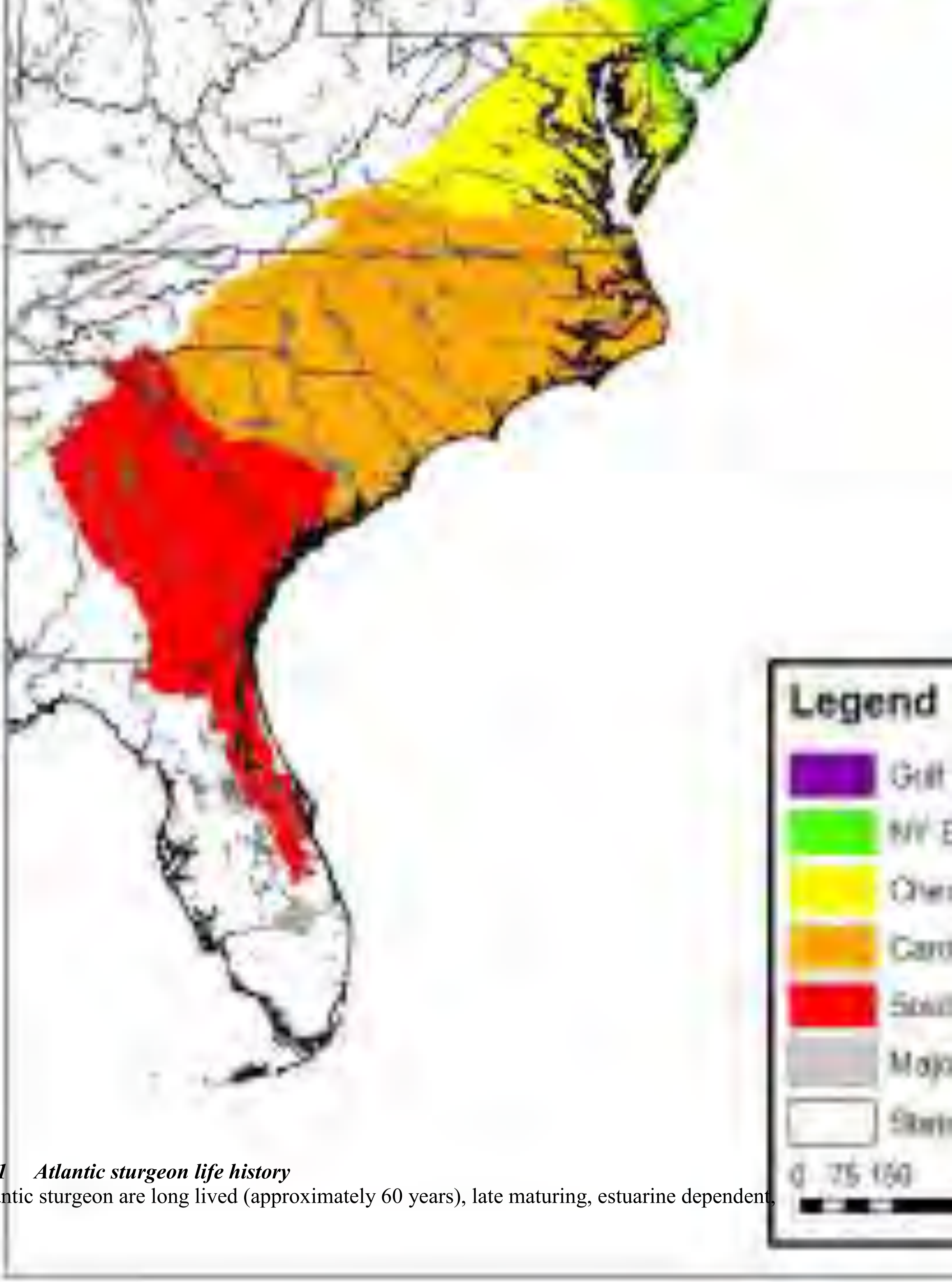
The results of the video sled survey in the Marcus Hook project area confirmed that sturgeons are using the area in the winter months. However, sturgeon relative densities in the project area were much lower than those observed near Trenton, New Jersey, even when the upriver counts were adjusted for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

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 then provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also provide a description of which Atlantic sturgeon DPSs likely occur in the action area and provide information on the use of the action area by Atlantic sturgeon.

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers. comm.). NMFS has delineated U.S. populations of Atlantic sturgeon into five DPSs[11] (77 FR 5880 and 77 FR 5914). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 3). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada

[11] 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.”



4.7.1 Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[12] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007).

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

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

Table 4. Descriptions of Atlantic sturgeon life history stages.

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

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that

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

originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20^{th} century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011). The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC, 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clugston, 1997; Caron *et al.*, 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Smith *et al.*, 1982; Dovel and Berggren, 1983; Smith, 1985; ASMFC, 2009), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren, 1983; Smith, 1985; Collins *et al.*, 2000), make rapid spawning migrations upstream, and quickly depart following spawning (Bain, 1997).

The spawning areas in most U.S. rivers have not been well defined. However, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 cm/s and depths are 3-27 m (Borodin, 1925; Dees, 1961; Leland, 1968; Scott and Crossman, 1973; Crance, 1987; Shirey *et al.* 1999; Bain *et al.*, 2000; Collins *et al.*, 2000; Caron *et al.* 2002; Hatin *et al.* 2002; ASMFC, 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009), and become adhesive shortly after fertilization (Murawski and Pacheco, 1977; Van den Avyle, 1983; Mohler, 2003). Incubation time for the eggs increases as water temperature decreases (Mohler, 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT, 2007).

Larval Atlantic sturgeon (i.e. less than 4 weeks old, with total lengths (TL) less than 30 mm; Van

Eenennaam *et al.* 1996) are assumed to undertake a demersal existence and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.*, 1980; Bain *et al.*, 2000; Kynard and Horgan, 2002; ASMFC, 2009). Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Haley, 1999; Hatin *et al.*, 2007; McCord *et al.*, 2007; Munro *et al.*, 2007) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.*, 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton, 1973; Dovel and Berggen, 1983; Waldman *et al.*, 1996; Dadswell, 2006; ASSRT, 2007).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 m in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Welsh *et al.*, 2002; Savoy and Pacileo, 2003; Stein *et al.*, 2004; USFWS, 2004; Laney *et al.*, 2007; Dunton *et al.*, 2010; Erickson *et al.*, 2011; Wirgin and King, 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 m during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 m in summer and fall (Erickson *et al.*, 2011). Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009) found a similar movement pattern for juvenile Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore fisheries with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (Dovel and Berggren, 1983; Dadswell *et al.*, 1984; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*, 2004; Stein *et al.*, 2004; Wehrell, 2005; Dadswell, 2006; ASSRT, 2007; Laney *et al.*, 2007). These sites may be used as foraging sites and/or thermal refuge.

4.7.2 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. 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%. 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 individuals 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%, South Atlantic 17-18%, and Gulf of Maine 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. No Carolina DPS fish have been documented in sampling carried out in the Delaware River or along the Delaware Coast. However, 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).

4.7.3 Distribution and Abundance

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

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

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

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

We were able to use this estimate of the adult population in the Hudson River and the rate at which Atlantic sturgeon from the Hudson River are intercepted in certain Northeast commercial fisheries[13] to estimate the number of adults in other spawning rivers. As noted above, the method used is summarized below and explained fully in Damon-Randall 2012(b).

Given the geographic scope of commercial fisheries as well as the extensive marine migrations of Atlantic sturgeon, fish originating from nearly all spawning rivers are believed to be intercepted by

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

commercial fisheries. An estimate of the number of Atlantic sturgeon captured in certain fisheries authorized by NMFS under Federal FMPs in the Northeast is available (NEFSC 2011). This report indicates that based on observed interactions with Atlantic sturgeon in sink gillnet and otter trawl fisheries from 2006-2010, on average 3,118 Atlantic sturgeon are captured in these fisheries each year. Information in the NEFOP database, indicates that 25% of captured Atlantic sturgeon are adults (determined as length greater than 150 cm) and 75% are subadults (determined as length less than 150cm). By applying the mixed stock genetic analysis of individuals[14] sampled by the NEFOP and At Sea Monitoring Program (see Damon-Randall *et al.* 2012a) to the bycatch estimate, we can determine an estimate of the number of Hudson River Atlantic sturgeon that are intercepted by these fisheries on an annual basis.

Given the number of observed Hudson River origin Atlantic sturgeon adults taken as bycatch, we can calculate what percentage of Hudson River origin Atlantic sturgeon mature adults these represent. This provides an interception rate. We assume that fish originating in any river in any DPS are equally likely to be intercepted by the observed commercial fisheries; therefore, we can use this interception rate to estimate the number of Atlantic sturgeon in the other rivers of origin. This type of back calculation allows us to use the information we have for the Hudson River and fill in significant data gaps present for the other rivers. Using this method, we have estimated the total adult populations for three DPSs (Gulf of Maine, Chesapeake Bay, and South Atlantic) as follows. It is important to note that this method likely underestimates the total number of adults in the SA DPS because genetic analysis of individuals observed through the NEFOP program indicate that only individuals from the Savannah and Ogeechee are being captured in Northeast fisheries considered in the NEFSC bycatch report. Spawning is known to occur in other rivers in the SA DPS, including the Altamaha (estimate of 343 adult spawners per year).

We are not able to use this method to calculate an adult population estimate for the Carolina DPS. Based on the results of the genetic mixed stock analysis, fish originating from the Carolina DPS rarely appear in the NEFOP dataset and based on this, as well as genetics information on fish captured in other coastal sampling programs in the Northeast are assumed to be only rarely intercepted in Northeast fisheries.

Given the proportion of adults to subadults in the observer database (ratio of 1:3), we can also estimate a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it would only consider 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.

Currently, there are an estimated 343 spawning adults in the Altamaha and there are estimated to be less than 300 spawning adults (total of both sexes) in each of the other major river systems occupied by the South Atlantic DPS. Spawning is thought to occur in six rivers in the SA DPS. Adding these estimates together results in a total adult population estimated of less than 1,843 mature adults. Our fishery dependent estimate is 390. This is likely an underestimate of the total number

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

of adults in the SA DPS because genetic analysis of individuals observed through the NEFOP program indicate that only individuals from the Savannah and Ogeechee are being captured in Northeast fisheries considered in the NEFSC bycatch report. Because of this, it is difficult to compare these two estimates. It may be reasonable to consider the estimate of 390 adults to be an estimate of the number of adults in the Savannah and Ogeechee rivers only. This would be consistent with the assumption that there are fewer than 300 adults in each of these two rivers.

While we are unable to calculate a population estimate for the Carolina DPS using the above methodology, we do have an estimate of 1500 adult spawners/year (5 spawning rivers x 300 spawning adults per river) described in the Atlantic sturgeon status review report. As noted above, for the South Atlantic DPS, using this method, the estimated number of fish in the South Atlantic DPS would be 1800 spawning adults (6 spawning rivers x 300 spawning adults per river). Therefore, the Carolina DPS has approximately 17% less fish than the South Atlantic DPS. Based on the methodology described above, the estimated number of mean annual mature adults for the South Atlantic DPS is 390 fish. Using the proportion of Carolina DPS fish to South Atlantic DPS fish, we estimate that the mean number of annual mature adults in the Carolina DPS is 324 (17% less than 390).

Table 5: Summary of Calculated Population Estimates from NER Fisheries Dependent Data

DPS	Estimated Adult Population	Estimated Subadults of Size vulnerable to capture in commercial fisheries
GOM	215	645
NYB (Hudson River and Delaware River)	951	2,853
CB	273	819
SA*	390	972
Carolina*	324	1,170

*see note re. South Atlantic and Carolina population sizes in paragraphs above.

4.7.4 Threats faced by Atlantic sturgeon throughout their range

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

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

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

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

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

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NEFSC 2011). The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%.

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

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

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

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

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

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

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

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

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

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

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 Connecticut and Taunton Rivers (ASSRT, 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT, 2007; Savoy, 2007; Wirgin and King, 2011).

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

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

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

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

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

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

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke

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

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

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

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

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 still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et al.*, 1994; ASSRT, 2007; Greene, 2009). However, conclusive evidence of current spawning is only available for the James River. Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat prior to entering the marine system as subadults (Vladykov and Greeley, 1963; ASSRT, 2007; Wirgin *et al.*, 2007; Grunwald *et al.*, 2008).

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

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

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

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

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

Summary of the Chesapeake Bay DPS
Spawning for the Chesapeake Bay DPS is known to occur in only the James River. Spawning may be occurring in other rivers, such as the York, but has not been confirmed. There are anecdotal

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

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

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 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 6). 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.

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	

Table 6. 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.

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 timeframe. Prior 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 abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, is estimated to be less than 3 percent of what they were historically (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 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. Atlantic sturgeon are more 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 percent 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 between 0 and 51 percent, 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. 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 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 have remained relatively constant at greatly reduced levels (approximately 3 percent of historical population sizes) 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. Their late age at maturity provides more opportunities for individual Atlantic sturgeon to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, it also results 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 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 estimated to number less than 3 percent of its historic population size. There are estimated 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, whose freshwater range occurs 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. Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. While a long life-span also 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 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, or even post-capture mortality. 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 passsage 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 7). 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.

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	

Table 7. 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.

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 abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, is estimated 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 Rivers. 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 (approximately 6 percent of historical population sizes in the Altamaha River, and 1 percent of historical population sizes in the remainder of the DPS) 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. Their late age at maturity provides more opportunities for individual Atlantic sturgeon to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, it also results 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 fewer than 6 percent of its historical population size, with all river populations except the Altamaha estimated to be less than 1 percent of 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. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. 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, or even post-capture mortality. 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 passsage 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. Data required to evaluate water allocation issues are either very weak, in terms of determining the precise amounts of water currently being used, or non-existent, in terms of our knowledge of water supplies available for use under historical hydrologic conditions in the region. 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 (river mile 148). Tagging studies by O'Herron et al. (1993) found that the most heavily used portion of the river appears to be between river mile 118 below Burlington Island and river mile 137 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 March[15], 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 8-9ºC with most spawning occurring when water temperatures are between 10 and 15ºC. Until recently, actual spawning (i.e., fertilized eggs or larvae) had not been documented in this area; however, the concentrated use of the Scudders Falls region in the spring by large numbers of mature male and female shortnose sturgeon indicated that this is the major spawning area (O'Herron et al. 1993). The same area was identified as a likely spawning area based on the collection of two ripe females in the spring of 1965 (Hoff 1965). 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 15ºC (although sturgeon have been reported on the spawning grounds at water temperatures as high as 18ºC), 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).

No studies have been conducted on juveniles in the Delaware River. As shortnose sturgeon demonstrate nearly identical migration patterns in all rivers, it is likely that juveniles in the Delaware River exhibit similar migration patterns to sturgeon in other river systems. As such, it is likely that yearlings are concentrated in the upper Delaware River above Philadelphia.

As noted above, due to limited information on juvenile shortnose sturgeon, it is difficult to ascertain

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[15] 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 15ºC 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.

their distribution and nursery habitat (O'Herron 2000, pers. comm.). 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 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 (river mile 54) to the Schuylkill River (river mile 92) (O'Herron 2000, pers. comm.). 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 river mile 127 and 134 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-November[16], 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 river mile 125 and river mile 148 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. Adult sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between river mile 118 and 131. The areas around Duck Island and Newbold Island seem to be regions of intense overwintering concentrations. However, unlike sturgeon in other river systems, shortnose sturgeon in the Delaware do not appear to remain as stationary during overwintering periods. Overwintering fish have been found to be generally active, appearing at the surface and even breaching through the skim ice (O'Herron 1993). Due to the relatively active nature of these fish, 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 1.24 river miles

[16] 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).

of the aggregation site (O'Herron and Able 1986). Investigations with video equipment by the ACOE in March 2005 (Versar 2006) documented two sturgeon of unknown 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 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. The overwintering location of juvenile shortnose sturgeon is not known but believed to be on the freshwater side of the oligohaline/fresh water interface (O'Herron 1990). In the Delaware River, the oligohaline/freshwater interface occurs in the area between Wilmington, Delaware and Marcus Hook, Pennsylvania (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. While shortnose sturgeon forage on a variety of organisms, in the Delaware River, sturgeon primarily feed on the Asiatic river clam (*Corbicula manilensis*). *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 on the trash racks of the Salem nuclear power plant in Salem, New Jersey at Artificial Island. The intakes for this plant are located in Delaware Bay. While the available information does not identify the area below Philadelphia as a concentration area for adult shortnose sturgeon, it is apparent that this species does occur in the lower Delaware River and upper Delaware Bay.

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 RM 78, approximately 20 miles 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 2.7 miles upstream of the project site, at RM 81), and one near the upstream end of the Cherry Island Flats (at RM 74; approximately 3.8 miles 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 fished 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 one each during the June, July and August sampling events. Two of the shortnose sturgeon were collected at RM 78 and one was taken at the downstream sampling station at RM 74. Total length ranged from 311-367mm. During the September – December sampling, one juvenile shortnose sturgeon was caught in September at RM 78 and one in November at the same location. One adult shortnose sturgeon was captured in October at RM 74. 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 (RM 74) 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 RM 93, Tinicum RM 86, Bellevue RM 73 and New Castle RM 58 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 fish tagged were adults tagged after collection in gill nets in the upper tidal Delaware River, between RM 126-132. 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 New Castle 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.

Information on the use of the river by juveniles is lacking and the information available is extremely limited (i.e., 5 captures). As evidenced by the Crown Landing study, juvenile shortnose sturgeon have been documented between RM 81-74 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. However, the April – August time frame is when flows in the Delaware River are highest and the time when the action area is likely to experience the low salinity levels preferred by juveniles (FERC 2005). Beginning in August, flows decrease and the salt wedge begins to move upstream, which may preclude juveniles from occurring in the action area. Based on this information, it is likely that juvenile shortnose sturgeon are present in the action area at least during the April – August time frame. The capture of juvenile shortnose sturgeon in the RM 81-74 range in November of 2005 suggests that if water conditions are appropriate, juveniles may also be present in this area through the fall. While it is possible, based on habitat characteristics, that this area of the river is used as an overwintering site for juveniles, there is currently no evidence to support this presumption.

In 2005, the ACOE 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 over wintering 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 two 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 sturgeons 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 sturgeons 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.

As described in the "Description of the Action" section above, dredging will occur in six river reaches (see Table 1 and 2). 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 30 miles 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.

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 RM 34 is considered polyhaline (18-30ppt), RM 34-44 is mesohaline (5-18ppt), RM 44-79 is oligohaline (0.5-5ppt), and Marcus Hook (RM 79) 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 RM 44 (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 RM 34. Due to the typical high salinities experienced in the polyhaline zone (below RM 34 (rkm 55)), shortnose sturgeon are likely to be rare in this reach of the river; this area covers part of Reach D and all of Reach E.

Both adult and juvenile shortnose sturgeon are likely to occur in reach AA (RM 102-97 (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 November[17]. 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. Similarly, reach A (RM 97-85) is also likely to be used by migrating shortnose

[17] 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.

sturgeon and for opportunistic foraging. This reach of the river includes the Torresdale Range (RM 93), 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. Reach B (RM 85-67) encompasses the Cherry Island Flats 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). 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 RM 67-55 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 sturgeon are likely to be present in this reach of the river when water temperatures are greater than 10°C (mid April – mid November). Reach D includes RM 55-41 and includes the area near Artificial Island. Shortnose sturgeon have occasionally been recorded at the Salem Nuclear Generating Facility intakes with at least 10 live sturgeon observed at the trash racks between April and early November since 1979. One dead shortnose sturgeon was observed at the intake in January 1978 and one in late November 2007. However, due to the level of decomposition observed with these fish, it is unlikely that they died at the intakes or that they died during the winter months. Shortnose sturgeon are likely to 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 RM 41- 5. Based on the best available information, including the high salinity levels in this reach, shortnose sturgeon are expected to be rare in this reach; 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 1830's indicate Atlantic sturgeon may have spawned as far north as Bordentown, just below Trenton, NJ (Pennsylvania Commission of Fisheries, 1897). Cobb (1899) and Borden (1925) reported spawning between rkm 77 and 130 (Delaware City, DE to Chester City, PA). Based on recent tagging and tracking studies carried out from 2009-2011, Breece (2011) reports likely spawning locations at rkm 120-150 and rkm 170-190. 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. Mature adults have been tracked in these areas at the time of year when spawning is expected to occur and movements have been consistent with what would be expected from spawning adults. Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat also exists from Tinicum Island (rkm 136) to the fall line in Trenton, NJ (rkm 211). To date, eggs and larvae have not been documented to confirm that actual spawning is occurring in these areas. However, as noted below, the 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 (rkm130) until their tags transmissions also ended in October (Fisher, 2011).

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

Adult Atlantic sturgeon captured in marine waters off of Delaware Bay in the spring were tracked in an attempt to locate spawning areas in the Delaware River, (Fox and Breece, 2010; 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

NMFS has 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 ACOE. As explained in the Consultation History section above, a batched consultation was completed in 1996 between NMFS and the ACOE on the effects of the ACOE'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 reinitiated 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, 4 loggerhead, 1 Kemp's ridley, and 1 green sea turtle. This take applies to the Philadelphia to Trenton project, maintenance of the 40-foot Philadelphia to the Sea channel, and the ACOE regulatory program where private dredging activities are authorized.

Dredging in the Philadelphia to Trenton project has caused 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 is 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 ACOE 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. 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. No shortnose or Atlantic sturgeon have been observed during any hopper dredging event. 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 used during any cutterhead dredging operations for this project or at any hopper dredge operation upstream of the Delaware Memorial Bridge.

The deepening project began in March 2010. Between March and September, 2010, approximately 3 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 1 million cy of material removed. No sturgeon or their parts have been observed at the disposal site.

5.1.3 Crown Landing LNG Project

On May 23, 2006 NMFS issued an Opinion to the Federal Energy Regulatory Commission (FERC) and the ACOE 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 US Army Corps of Engineers (ACOE) 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 ACOE. 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, NMFS 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 US 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 will cease operations in 2036 and Salem Unit 2 will cease operations in 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

NMFS in April 1980 in which NMFS 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 NMFS 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 NMFS modify the Reasonable and Prudent Measures and Terms and Conditions of the ITS, and, specifically, remove a sea turtle study requirement. NMFS 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. With the exception of 1991 and 1992, when 23 and 10 sea turtles were captured at the intakes, the actual level of take has been far lower than the exempted level. Inclusive of 1991 and 1992, for the period between 1979 and 1992, a total of 2 green, 23 Kemp's ridley and 60 loggerheads have been captured at the intakes. Since monitoring of the intakes was initiated in 1978, 18 shortnose sturgeon have been recovered from the Salem intakes. No shortnose sturgeon or sea turtles have been observed at the Hope Creek intakes. No sea turtles have been captured at Salem since 2001. Two Atlantic sturgeon, both previously dead, have been observed at the Salem intakes; none have been observed at the Hope Creek intakes. Consultation was reinitiated in 2011; we are currently in the process of preparing an updated Biological Opinion considering effects of ongoing operations on sea turtles, shortnose sturgeon and Atlantic sturgeon.

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, NMFS 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 affect 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 NMFS 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 five year life of the permit. This permit expires on April 19, 2015.

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.

The Delaware Department of Natural Resources and Environmental Control (DNREC) holds a scientific research permit (#14396) authorizing research on shortnose sturgeon. DNREC is authorized to capture, handle and tag 215 shortnose sturgeon. The unintentional mortality of one adult or juvenile shortnose sturgeon is anticipated over the five year life of the permit. This permit expires on December 13, 2014.

5.1.7 Vessel Operations

Potential adverse effects from federal vessel operations in the action area of this consultation include operations of the US Navy (USN) and the US Coast Guard (USCG), which maintain the largest federal vessel fleets, the EPA, the National Oceanic and Atmospheric Administration (NOAA), and the ACOE. NMFS has conducted formal consultations with the USCG, the USN, EPA and NOAA on their vessel operations. In addition to operation of ACOE vessels, NMFS has consulted with the ACOE to provide recommended permit restrictions for operations of contract or private vessels around whales. Through the section 7 process, where applicable, NMFS has 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 the ACOE. 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 the ACOE. 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 anticipate that some states are likely to apply for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no applications have been submitted. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon.

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 has 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 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 horeshoe 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 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-striped bass fishery had an Atlantic sturgeon bycatch rate of 16% from 1989-2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of 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.

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 is 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 is 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 semivolatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs 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 ship strike. Shortnose sturgeon may not be as susceptible due to their smaller size in comparison to Atlantic sturgeon that are larger and for which ship strikes have been documented more frequently. However, anecdotal evidence suggests that shortnose sturgeon at least occasionally interact with vessels, as evidence by wounds that appear to be caused by propellers. There has been only one confirmed incidence of a ship strike on a shortnose sturgeon and 2 suspected ship strike mortalities. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20) ft boat transiting a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. The other two suspected ship strike mortalities occurred in the Delaware River. On June 8, 2008, a shortnose was collected near Philadelphia. The fish was necropsied and found to have suffered from blunt force trauma; though there was no ability to confirm whether the source of the trauma resulted from a vessel interaction. Lastly, on November 28, 2007, a shortnose sturgeon was collected on the trash racks of the Salem Nuclear Generating Facility. The fish was not necropsied, however, a pattern of lacerations on the carcass suggested a possible vessel interaction. Aside from these incidents, no information on the characteristics of vessels that are most likely to interact with shortnose sturgeon is available and there is no information on the rate of interactions, however it is assumed to be low.

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 0.76ºC (1.36°F) over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a) and precipitation has increased nationally by 5%-10%, mostly due to an increase in heavy downpours (NAST 2000). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b); these trends are most apparent over the past few decades. Information on future impacts of climate change in the action area is discussed below.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 3^{o}-5^{o}C (5^{o}-9^{o}F) on average in the next 100 years which is more than the projected global increase (NAST 2000). A warming of about 0.2^{o}C (0.4°F) per decade is projected for the next two decades over a range of emission scenarios (IPCC 2007). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene *et al.* 2008).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene *et al.* 2008, IPCC 2006). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2006). The NAO impacts climate variability throughout the northern hemisphere (IPCC 2006). Data from the 1960s through the present show that the NAO index has increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2006). This warming extends over 1000m (0.62 miles) deep and is deeper than anywhere in the world oceans and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2006). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene *et al.* 2008, IPCC 2006). There is evidence that the NADW has already freshened significantly (IPCC 2006). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene *et al.* 2008).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on coastal and marine resources on smaller geographic scales, such as the 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 unimpacted, free-flowing rivers (Palmer *et al.* 2008).

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

6.2 Species Specific Information 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. However, 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.

However, Van Houtan and Halley (2011) recently 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 effect the South Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, 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, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the saltwedge. It is unlikely that shifts in the location of the saltwedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

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

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

6.3 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 ACOE for the deepening project have considered climate change (ACOE 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 sealevel 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 sediments 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.

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 river mile 71. 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 river mile 114 (rkm 183) in 2050 and 117 (rkm 188) in 2100. The farthest north the salt line has historically been documented was approximately river mile 103 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 11 miles further upstream by 2050 and 14 miles 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; however, we have considered the available information to consider likely impacts to sturgeon in the action area. The proposed action under consideration of the continuation of the deepening project through January 2017 and 10 years of maintenance dredging; thus, we consider here, likely effects of climate change during the period from now until 2027.

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 ACOE 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 spanwing 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. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift 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 is 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 considered the available information to consider likely impacts to these species in the action area. The proposed action under consideration of the continuation of the deepening project through January 2017 and 10 years of maintenance dredging; 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 not to die 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 that hatchlings would be present in the action area.

We have considered whether the disposal of sand at Broadkill Beach and Kelly Island 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 (15 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 and Kelly Island 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, 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, the disposal of dredged material resulting from this dredging, including beneficial use of material at Broadkill Beach and Kelly Island, blasting of rock material at Marcus Hook and subsequent removal with a mechanical dredge, as well as 10 years of maintenance dredging.

As explained in the Description of the Action section above, both hydraulic cutterhead and hopper dredges will be used for the initial deepening. It is also possible that a mechanical dredge could be used in Reach AA. Refer to Table 2 and Figure 2 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 10 years of maintenance dredging.

7.1 Hopper Dredge

A large self-propelled hopper dredge will be used for dredging in Reach E and may also be used in Reach AA, A and D. At Reach A, dredging is scheduled over approximately six months from August 2012-February 2013 (1,666,600cy to be removed); at this time it is unknown if a cutterhead or a hopper dredge will be used. Dredging at Reach E will occur with a hopper dredge, with disposal at Broadkill Beach (1,598,700 cy) is scheduled for September – December 2013; dredging at Reach E will also occur with disposal at Kelly Island (2,483,000 cy) between April and August 2015. Dredging at Reach AA will be with a cutterhead or hopper dredge and will remove 994,000 cy from August – November 2014. Dredging at Reach D is likely to be with a hopper dredge but could occur with a cutterhead dredge; dredging will occur from December 2012 – June 2013.

7.1.1 Entrainment in Hopper Dredges – Sea Turtles

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. No sea turtles occur in Reach A or AA so no sea turtles will be exposed to effects of hopper dredging carried out in Reach A or AA.

Deepening will remove 2,051,100 cy from Reach D and a total of 4,981,700 cy from Reach E. Dredging is scheduled in Reach D from December 2012 – June 2013 and in Reach E from September – December 2013 and April – August 2015. Exact scheduling is dependent on funding and availability of dredge equipment.

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 ACOE, no leatherback sea turtles have been entrained in hopper dredge operations operating along the U.S. Atlantic coast (ACOE 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.

Sea turtles become entrained in hopper dredges as the draghead moves along the bottom. Entrainment occurs when sea turtles do not or cannot escape from the suction of the dredge. Sea turtles can also be crushed on the bottom by the moving draghead. Mortality most often occurs when turtles 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. 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 the ACOE 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.

Sea turtles have been found resting 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. While sea turtle brumation has not been documented in mid-Atlantic or New England waters, it is possible that this phenomenon occurs in these waters.

7.1.1.1 Background Information on Entrainment of Sea Turtles in Hopper Dredges
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 ACOE South Atlantic Division (SAD; i.e., south of the Virginia/North Carolina border) are more common than in the ACOE 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 ACOE SAD, over 400 sea turtles have been entrained in hopper dredges since 1980 and in the Gulf Region over 160 sea turtles have been killed since 1995. Records of sea turtle entrainment in the ACOE NAD began in 1994. Through May 2012, 75 sea turtles deaths (see Table 8) related to hopper dredge activities have been recorded in waters north of the North Carolina/Virginia border (USACE

Sea Turtle Database[18]); the majority of these turtles have been entrained in dredges operating in Chesapeake Bay.

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, 6 have occurred in the Philadelphia District, 3 in the Baltimore District and 1 in the New York District. As explained in the ACOE 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.

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

In addition to sea turtles observed as entrained, one loggerhead was killed during dredging operations off Sea Girt, New Jersey during an ACOE 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 8. Sea Turtle Takes in USACE NAD Dredging Operations

Project Location	**Year of Operation**	**Cubic Yardage Removed**	**Observed Takes**
Cape Henry Channel	2012	NA	1 loggerhead
York Spit	2012	NA	1 Loggerhead
Thimble Shoal Channel	2009	NA	3 Loggerheads
York Spit	2007	608,000	1 Kemp's Ridley
Cape Henry	2006	NA	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	6 Loggerheads 1 Kemp's ridley 1 green
VA Beach Hurricane Protection Project (Cape Henry)	2002	NA	1 Loggerhead
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	NA	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	NA	1 Loggerhead
Delaware Bay	1993	NA	2 Loggerheads
Off Ocean City MD	1992	1,592,262	3 Loggerheads
			TOTAL = 75 Turtles

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., 6 hours on watch, 6 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), NMFS 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.

NMFS raised this issue to the ACOE 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 ACOE 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. The ACOE'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. More recently issued Opinions have required 100% observer coverage which increases the likelihood of takes being detected and reported.

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, 2 Kemp's ridleys, and 1 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 3 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 crush 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 in the examples of sea turtle takes above. 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 3 separate weeks while dredging at York Spit in 1994 resulted in 4 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 this date, 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. 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, 7 projects involved dredging in the Philadelphia to the Sea navigation channel and 5 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 9 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 a 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 there was only 50% observer coverage, 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, NMFS has assumed that an equal number of turtles were entrained when observers were not present. This calculation is reflected in Table 2 as "adjusted entrainment number."

Table 9. Sea turtle entrainment in Philadelphia District dredging operations

Project	Dates	CY Removed	Observed Entrainment	Adjusted Entrainment Number
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	11/01/2005 - 11/18/2005	167,982	0	0

Ranges				
Philadelphia to the Sea - Miah Maull and Brandwine	10/04/05 - 10/22/2005	162,682	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	275,000	2	4
TOTAL		4,093,815	6	9

7.1.1.2 Predicted Entrainment in Proposed Hopper Dredging

Based on the data in Table 9, NMFS has made calculations which indicate that an average of one sea turtle is killed for approximately every 450,000 cy removed. 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 450,000 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, includes multiple projects over several years, and all of the projects 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 ACOE NAD have been loggerheads and Kemp's ridley. Of these 75 sea turtles, 65 have been loggerheads, 5 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 ACOE 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.

Based on the above information, it is reasonable to expect that one sea turtle is likely to be injured or killed for approximately every 450,000 cy of material removed from Reach D and E between May and November, and that at least 90% will be loggerheads. The ACOE has provided us with a schedule that indicates during what months dredging in Reach D and E is expected to occur; because sea turtles do not occur in the action area from December – April, we do not expect any entrainment during these months. Based on the information outlined above and the volume of material estimated to be removed from each reach during the time of year when sea turtles are likely to be present, we anticipate the following levels of entrainment:

Reach	**Scheduled Dates**	**Total Volume**	**May – November Volume**	**Expected Sea turtle interactions**
D	Dec 2012 – June 2013	2,051,100	586,028	2
E	Sept – Dec 2013	1,598,700	1,200,025	3
E	April – Aug 2015	2,483,000	2,483,000	6
			Total:	11

As such, assuming that all three of these reaches are deepened with hopper dredges, we anticipate that no more than 11 sea turtles are likely to be entrained in the initial dredge cycle operating on the schedule outlined above. 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 ACOE 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 ACOE NAD, no more than 1 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.

7.1.2 Entrainment – Shortnose Sturgeon

Shortnose sturgeon are also vulnerable to entrainment in hopper dredges. 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 sturgeon have been documented during any hopper dredge activity in the Philadelphia to the Sea channel maintenance. Little is known about the distribution of shortnose sturgeon in Delaware Bay. However, shortnose sturgeon have been documented at the Salem Nuclear Generating Facility at Artificial Island. The known occurrence of shortnose sturgeon in Reaches D and E and the lack of documented occurrence of entrainment of shortnose sturgeon in other hopper dredging operations in this area and the extent of the observer coverage (i.e., at least

25% coverage over 7 events over 15 years) leads to the conclusion that it is extremely unlikely that a shortnose sturgeon will become entrained in a hopper dredge operating in Reach D or Reach E. This is likely due to the low number of shortnose sturgeon in these reaches (due to high salinity). Additionally, tracking studies conducted by O'Herron (1985) in the Bay, indicate that sturgeon were not typically found in the deepwater channel, but were more common outside the channel and on the channel edges. This distribution is likely to reduce the likelihood of an interaction between a dredge operating in the Bay and a shortnose sturgeon. Based on this information and the lack of interactions with shortnose sturgeon during dredging in this area in the past, no shortnose sturgeon are likely to be injured or killed during hopper dredging operations at these reaches.

A hopper dredge will also be used for deepening at Reach A and Reach AA. Dredging at Reach A will remove 1,666,600 cy between August 2012 and February 2013. Dredging in Reach AA will remove 994,000 cy between August and November 2014. Shortnose sturgeon are likely to be present in these river reaches between April and November.

Dredging of this reach of the navigation channel has occurred routinely in the past. However, no observers have been present on board the dredge. As such, there is no information on any historic interactions that may have occurred. Because location specific information is not available, we have considered information on hopper dredge interactions in other river systems. A hopper dredge is used to maintain the Kennebec River Federal Navigation Project (Maine; see Table 10 below). Over the past 20 years, dredging in the channel with a hopper dredge has occurred six times. Shortnose sturgeon have only been entrained during two of these events, with a total of seven sturgeon entrained. Considering the six dredging events that have occurred over the past 20 years, an entrainment rate of 1 shortnose sturgeon for every 30,000 cy is calculated for the Kennebec River. Hopper dredges are also used to maintain the Hudson River navigation channel in New York. However, dredging is timed to minimize the potential for shortnose sturgeon occurrence in the area being dredged. No endangered species observers are used and no interactions with shortnose sturgeon have been reported to NMFS or the ACOE.

Table 10. Maintenance dredging of the lower Kennebec River FNP since 1991.

Location	Dates	Volume Removed (cy)	Observer Present?	Interactions with Shortnose Sturgeon
Doubling Point	Fall 1991	69,000	No	2 lethal
Doubling Point	November 1997	22,000	Yes	0
Doubling Point	December 2000	20,000	Yes	0
Doubling Point	April 2002	25,000	Yes	0
Doubling Point	10/6-10/10/2003	22,310	Yes	3 lethal 2 injured but alive upon release
Doubling Point	August 2011	50,000	No	0

We have also considered information on shortnose sturgeon interactions with other dredge types. Complete data sets from three cutterhead dredging events in the upper Delaware River are available (see Table 11 below). As explained in the cutterhead dredging section below, five shortnose sturgeon have been observed entrained during two separate dredging events in the upper Delaware River with the fish observed at the Money Island disposal site. Complete data is also available for two cutterhead dredging events that have occurred for the deepening of the Delaware main channel. Dredging occurred in Reach C in 2010 and in Reach B in 2011. The dredge disposal sites were inspected daily during the 2010 and 2011 dredge events. No shortnose sturgeon were observed entrained during either deepening event. Using these four dredge events, the calculated entrainment rate is one shortnose sturgeon for approximately every 1.1 mcy of material removed.

Table 11. Shortnose Sturgeon Observations during Delaware River Dredging

Project	Type of Dredge	Dates	CY Removed	Sturgeon Observed
Kinkora to Trenton	Cutterhead	March 1996	509,946	2
Kinkora to Trenton	Cutterhead	January 1998	512,923	3
Reach C	Cutterhead	March – September 2010	3,594,963	0
Reach B (rkm 113.3-118)	Cutterhead	Nov – December 2011	1,100,000	0

We have also considered information on interactions between hydraulic dredges and other sturgeon species. The ACOE reports records of 29 interactions between dredges and sturgeon on the U.S. Atlantic coast between 1990 and 2010 (ACOE unpublished information). This number includes the 10 interactions discussed above (Kennebec River and Delaware River). At least two of the 29 entrained sturgeon were likely killed prior to entrainment based on the degree of decomposition. NMFS is aware of three additional interactions that were not included in this report, including two Atlantic sturgeon entrained during dredging in the Chesapeake Bay in May 2011 and 1 shortnose sturgeon captured in a dredge bucket operating at Bath Iron Works, Kennebec River, Maine in 2008 (released alive and unharmed). The ACOE and their contractors remove millions of cubic yards of material from rivers and coastal navigation channels, as well as offshore sand borrow areas, every year. Interactions with sturgeon remain a rare event, even in areas where sturgeon are relatively numerous.

Limited information is available on the likely entrainment rates and it is difficult to make a comparison between the likelihood of entrainment in a hopper dredge vs. a cutterhead dredge. However, it is likely that aquatic organisms, including shortnose sturgeon, may be more vulnerable to entrainment in a hopper dredge than a cutterhead. This is due to the larger size of the hopper draghead, the stronger suction and the faster speed at which the draghead moves which may make escape more difficult. A cutterhead dredge has a smaller intake, moves more slowly and is typically buried in the sediment. While in theory the risk of entrainment is likely higher in a hopper dredge than a cutterhead dredge, there is no quantitative way to calculate the difference in the level of risk.

While neither the Money Island dataset (2 events), the 2010-2011 Reach B and C dredging, or the Kennebec River dataset (6 events) are perfect estimates of the risk of entrainment in a hopper operating in these reaches, the Delaware River data sets, when combined, allow NMFS to calculate a risk of entrainment. NMFS believes that using this dataset of four Delaware River cutterhead dredging events is reasonable because it is based on dredging events in the same river system and incorporates entrainment data from the same dredge types at times of year when shortnose sturgeon were likely present in the areas being dredged and the dredge disposal sites were inspected with a goal of detecting any entrained sturgeon. Using these data sets, an entrainment rate of 1 shortnose sturgeon per approximately every 1.1 million cy of material removed is calculated.

Based on the above information, we expect one shortnose sturgeon to be entrained for approximately every 1,100,000 cy of material removed from Reach A and AA between April and November. No entrainment of shortnose sturgeon is anticipated in Reach D or E. The ACOE has provided us with a schedule that indicates during what months dredging in Reach A and AA is expected to occur; because we expect shortnose sturgeon to be overwintering outside Reach A from December – March, we do not expect any entrainment in Reach A during these months. Based on the information outlined here, we anticipate the following levels of entrainment:

Reach	**Scheduled Dates**	**Total Volume**	**April – November Volume**	**Expected shortnose sturgeon interactions**
A	Aug 2012 – Feb 13	1,666,600	1,000,000	1
AA	August – November 2014	994,000	994,000	1
E	Sept – Dec 2013	1,598,700	1,698,700	0
E	April – Aug 2015	2,483,000	2,483,000	0
D	Dec 2012 – June 2013	2,051,100	293,014	0

This calculation has been based on a number of assumptions including the following: that shortnose sturgeon are evenly distributed throughout all channel reaches used in this estimate, that all dredges will have the same entrainment rate, and that shortnose sturgeon are equally likely to be encountered throughout the time period when dredging will occur. While this estimate is based on several assumptions, it is reasonable because it uses the best available information on entrainment of shortnose sturgeon from past dredging operations, including dredging operations in the action area, it includes multiple projects over several years, and all of the projects have had observer coverage at the disposal site specifically looking for sturgeon.

There is evidence that some shortnose sturgeon, particularly juveniles or smaller adults, 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 shortnose sturgeon entrained in the hopper dredge are likely to be killed.

7.1.3 Hopper Dredge Entrainment – Atlantic Sturgeon

Atlantic sturgeon are vulnerable to entrainment in hopper dredges. 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. No Atlantic sturgeon have been documented during any hopper dredge activity in the Philadelphia to the Sea maintenance dredging. Observers have not been used for hopper dredge activities in other reaches of the river.

Given the large size of adults (greater than 150cm) and the size of the openings on the dragheads, adult Atlantic sturgeon are unlikely to be vulnerable to entrainment. ACOE reports that from 1990-2011, 30 interactions with sturgeon occurred during dredge operations. Of these, 17 were reported as Atlantic sturgeon, with 15 of these entrained in hopper dredges. Of the entrained Atlantic sturgeon for which size is available, all were subadults (larger than 50cm but less than 150cm). Information on these interactions is presented in Table 12. Most of these interactions occurred within rivers and harbors.

Table 12. USACE Atlantic Sturgeon Entrainment Records from Hopper Dredge Operations 1990-2011

Project Location	Corps Division/District*	Month/Year of Operation	Cubic Yards Removed	Observed** Entrainment
Winyah Bay, Georgetown (SC)	SAD/SAC	Oct-90	517,032	1
Savannah Harbor (GA)	SAD/SAS	Jan-94	2,202,800	1
Savannah Harbor	SAD/SAS	Dec-94	2,239,800	2
Wilmington Harbor, Cape Fear River (NC)	SAD/SAW	Sep-98	196,400	1
Charleston Harbor (SC)	SAD/SAC	Mar-00	5,627,386	2
Brunswick Harbor (GA)	SAD/SAS	Feb-02	1,459,630	1
Charleston Harbor	SAD/SAC	Jan-04	1,449,234	1
Brunswick Harbor	SAD/SAS	Mar-05	966,000	1
Brunswick Harbor	SAD/SAS	Dec-06	1,198,571	1
Savannah Entrance Channel	SAD/SAS	Nov-07	973,463	1
Sandy Hook Channel (NJ)	NAD/NANY	Aug-Nov-08	23,500	1

York Spit (VA)	NAD/NAN	Apr-11	1,630,713	2
		Total	**17,553,816**	**15**

* SAD= South Atlantic Division; NAD= North Atlantic Division; SAC=Charleston District; SAS=Savannah District; SAW=Wilmington District; NANY=New York District; NAN=Norfolk District.

** Records based on sea turtle observer reports which record listed species entrained as well as all other organisms entrained during dredge operations.

In general, entrainment of large mobile animals, such as Atlantic 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.

As noted above, no Atlantic sturgeon have been observed entrained in hopper dredges operating in the Delaware River. The only instances of Atlantic sturgeon entrainment in hopper dredges in the NMFS Northeast Region are two sturgeon entrained at York Spit, VA in 2011 (both were killed) and one live Atlantic sturgeon entrained in Sandy Hook, NJ in 2008. As described in the discussion of shortnose sturgeon and sea turtles above, many other hopper dredge projects have occurred in the Northeast Region; nearly all of which overlap with times and areas where Atlantic sturgeon are known to be present. Because observers have been present on these dredges and we expect that any interactions with Atlantic sturgeon would have been reported to us, the interaction rate between hopper dredges and Atlantic sturgeon seems to be very low. Even just considering the projects listed in Table 12, where entrainment was recorded, we calculate an entrainment rate of one Atlantic sturgeon for approximately every 1.2 million cy of material removed. If we included projects where observers were present and no Atlantic sturgeon were observed, the entrainment rate is even lower. Even just adding in the seven Delaware Bay projects and the six Kennebec projects presented in Tables 10 and 11 above, lowers the entrainment rate to one Atlantic sturgeon for every 1.5 mcy.

As noted above for sea turtles, there is a relationship between the number of animals entrained and the volume of material removed. The volume of material removed is correlated to the amount of time spent dredging but is a more accurate measure of effort because reports often provide the total days of a project but may not provide information on the actual hours of dredging vs. the number of hours steaming to the disposal site or in port for weather or other delays. Using just the information available for hopper dredging projects in the action area, we would expect no Atlantic sturgeon entrainment because none has been observed. However, because observers have not been used on hopper dredges outside of Reach D and E, it is possible that this would be an underestimate of the potential for entrainment outside of those reaches. However, it does suggest that entrainment in reaches D and E is likely to be very low. As noted above, tracking of sturgeon in Delaware Bay indicates that they are more likely to occur outside the channel and along the channel edges than within the deepwater channel; this likely reduces the risk of entrainment because it minimizes the co-occurrence of the dredge and sturgeon. The entrainment estimate generated above using the projects in rivers and bays where entrained Atlantic sturgeon have been observed plus the Kennebec and Delaware Bay hopper dredge projects, is an overestimate because it does not consider other projects where no entrainment occurred. However, at this time, it is the best available estimate of in-river entrainment rates for Atlantic sturgeon and hopper dredges.

Based on the above information, we expect one Atlantic sturgeon to be entrained for approximately every 1,500,000 cy of material removed with a hopper dredge. Given the size of adult Atlantic sturgeon (greater than 150cm) and the size of observed entrained sturgeon (less than 150cm), we do not anticipate the entrainment of any adult Atlantic sturgeon; all entrainment will be YOY, juveniles or subadults. Because observers have been used for dredging at Reach D and E in the past and no entrainment of Atlantic sturgeon has been observed, we do not anticipate any future entrainment of Atlantic 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, 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 the information outlined here, we anticipate the following levels of entrainment:

Reach	**Scheduled Dates**	**Total Volume**	**Expected Atlantic sturgeon interactions**
A	Aug 2012 – Feb 13	1,666,600	1
AA	August – Nov 2014	994,000	1
E	Sept – Dec 2013	1,598,700	0
E	April – Aug 2015	2,483,000	0
D	Dec 2012 – June 2013	2,051,100	0

There is evidence that some Atlantic 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 Atlantic sturgeon entrained in the hopper dredge are likely to be killed. 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.

7.1.4 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 (ACOE 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. The ACOE has indicated that overflow is not authorized for the deepening project. 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 8 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. No significant change above background levels could be detected. At 1-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.

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 or whale 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 8 minutes. Based on this information, any increase in suspended sediment is not likely to affect the movement of sea turtles between foraging areas or while migrating or otherwise negatively affect listed species in the action area. Based on this information, it is likely that the effect of the suspension of sediment resulting from dredging operations will be insignificant.

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 4 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 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

Table 13 describes work to be done with a cutterhead dredge. Dredging in Reach B is planned with a cutterhead dredge; dredging in Reaches AA, A and D could occur with a cutterhead or hopper dredge.

Table 13. Scheduled dredging by reach, date and volume to be removed

Channel Reach	Volume (CY)	Scheduled Dates
AA	994,000	August – November 2014
A	1,666,600	August 2012 – February 2013
B	3,485,469	August 2016 – January 2017
D	2,051,100	December 2012 – June 2013

Sea turtles are extremely unlikely to occur in Reaches AA, A and B and therefore would not be exposed to effects of dredging in these reaches. Sea turtles are seasonally present in Reach D. However, sea turtles are not known to be vulnerable to entrainment in cutterhead dredges. This is thought to be due to the size of sea turtles and their swimming ability that allows them to escape the intake velocity near a cutterhead. There are no records of any sea turtles being entrained in cutterhead dredges in the Delaware River or anywhere else. Based on the available information, we do not anticipate any entrainment of sea turtles in any reaches when a cutterhead dredge is used.

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, ACOE 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 and Reach B. 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. In both 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 ACOE 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). Based on the known intake velocities of several sizes of cutterhead dredges. 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.

The entrainment of five sturgeon in the upper Delaware River 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 areas where cutterhead dredging will occur for the deepening. 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. Sturgeon in that areas where dredging with the cutterhead dredge will occur are likely to be more active as evidenced by the movements of sturgeon tracked through Reach B in November through the end of December (ERC 2012).

In total, approximately 8.2 million cy of material will be removed with a cutterhead dredge for the deepening (inclusive of approximately 5.6 million cy of material that will be removed from Reach AA, A and D with either a cutterhead or hopper dredge) during a total of four dredge events. 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 in the 2012-2013 dredging of Reaches A and D, no more than one Atlantic sturgeon and no more than one shortnose sturgeon will be entrained in the 2014 dredging of Reach AA and no more than one

Atlantic sturgeon will be entrained in the 2016-2017 dredging of Reach B. The entrained shortnose sturgeon could be a juvenile or adult. The entrained Atlantic sturgeon could be a young of year, juvenile or subadult. 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 3 miles of pipe and any residency period in the disposal area, all entrained shortnose and Atlantic sturgeon are expected to be killed.

7.1.2.2 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 ACOE, 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 5mg/L, the modeling results indicated that elevated TSS concentrations (i.e., above background levels) would be present at the bottom 2 meters of the water column for a distance of approximately 1,150 feet. Based on these analyses, elevated suspended sediment levels are expected to be present only within 1,150 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 U. Washington 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 580mg/L to 700,000mg/L depending on species. Sublethal effects have been observed at substantially lower turbidity levels. For example, prey consumption was significantly lower for striped bass larvae tested at concentrations of 200 and 500 mg/L compared to larvae exposed to 0 and 75 mg/L (Breitburg 1988 in Burton 1993). Studies with striped bass adults showed that pre-spawners did not avoid concentrations of 954 to 1,920 mg/L to reach spawning sites (Summerfelt and Moiser 1976 and Combs 1979 in Burton 1993). While there have been no directed studies on the effects of TSS on shortnose or Atlantic sturgeon, 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 one of the presumed Atlantic sturgeon spawning sites. Dredging is scheduled to begin in these 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 4 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 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 Reaches AA, A, B, and D will be disposed of at an upland location. 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 3 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 Reach E, approximately 4 million cy of material will be disposed of at the Kelly Island and Broadkill Beach disposal areas. 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 (ACOE 1983). For this project, the ACOE 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 77,000 cubic yards of bedrock, covering 18 acres near Marcus Hook, Pennsylvania (River Mile 76.4 to River Mile 84.6) would be removed to deepen the navigation channel in this area. Blasting will occur at Reach B (Marcus Hook) from December 2013- January 2014 with mechanical rock removal continuing through February 2014. During this time of year, the majority of adult shortnose sturgeon are expected to be located at the overwintering area between mile 118 and 131 which is over 33 river miles from the blasting site (RM 76.4-84.6).

Studies conducted by the ACOE in March 2005, indicate that sturgeon are present in the Marcus Hook area 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) indicates that there are 0.005 sturgeon/100 m, or one sturgeon per 20,000m.

Blasting operations would occur up to five days a week during the December – January blasting period, but the actual blasting would only occur for a brief period each day. 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 the benthic community and reduced foraging opportunities.

The blasting plan has been designed to minimize the potential for fish mortality. As such, as noted above, all blasting will occur between December and January when fish density is expected to be lowest. Controlled blasting methods will be employed such as delayed blasting and "stemming" to reduce the amount of energy that would impact fish. In addition, fish avoidance techniques will be utilized to drive fish away from the proposed blasting area to reduce the detrimental impact to the fish and benthic community. Monitoring impacts to fish from the blasting will also be conducted to verify that impacts are minimal. Additionally, the following measures will be taken:

- 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. 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. Some marine mammals and 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 series of 5 blasts, 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.

- Surveillance for schools of fish will be conducted by vessels with sonar fish finders for a period of 20 minutes before each blast, and if fish schools are detected, blasting will be delayed until they leave. The surveillance zone will be approximately circular with a radius of about 500 feet extending outward from each blast set.

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 msec 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 4 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 1 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

The distribution of adult sturgeon in the lower Delaware River is relatively unknown. While the immediate area to be blasted (river mile 76.4 to river mile 84.6) is not a known concentration area for adult shortnose sturgeon, the species has been documented below Philadelphia and in the vicinity of the blasting area. Due to the lack of studies on overwintering sturgeon outside of the known upstream concentration area, the best available information is the survey conducted by ACOE in 2005 (Versar 2006). As noted above, in this study, video and net sampling was conducted with three sturgeon observed on video in the Marcus Hook area and no shortnose sturgeon captured with any nets. Atlantic sturgeon are known to occur in the Marcus Hook area year round, with this area recognized as a concentration area for juveniles.

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. The presence of adults and/or juveniles in the action area during blasting could result in injury and/or mortality. The severity of the impact that blasting has on fish is dependent on several biological and physical variables. The physical variables are 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(Teleki and Chamberlain 1978). The interactions of other factors such as composition of explosive, water depth, and bottom composition, determine the extent of the pressure wave and consequential fish kills (Teleki and Chamberlain 1978). 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 ceolomic 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 lead 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.

The ACOE will utilize measures to minimize the potential for blasting to occur if shortnose or Atlantic sturgeon are within 500 feet of the blast site. The ACOE will use a combination of sonar and other imaging (video or DIDSON for example) techniques to monitor an area with a radius of 500 feet surrounding the blast site. Outside of the 500 foot zone, no effects to fish are likely (ACOE 2008 and ACOE 2009). Monitoring will begin 20 minutes prior to the detonation and no blasting will occur until any fish observed have left the area. As such, the risk of shortnose or Atlantic sturgeon being within close enough proximity to be injured or killed during a detonation is low. However, as the survey will need to stop at some point so that detonation can begin, there is a small risk that a sturgeon could swim into the area prior to or during blasting and not be detected. As this is likely to be a rare occurrence, it is not likely to happen more than once during the entirety of the blasting period. Based on the density estimates of sturgeon in the Marcus Hook area (0.005/100m) NMFS has estimated that at any given time, no more than 3 sturgeon are likely to occur in an area at Marcus Hook with a radius of 500 feet. As such, it is reasonable to expect that if the monitoring is not successful, then no more than 3 sturgeon will be close enough to the detonation site to experience effects ranging from temporary stunning to death. As explained above, sturgeon within 500 feet of the blast are expected to experience effects that could range from avoidance of the area to mortality. As such, we expect that over the course of the winter when blasting occurs, no more than 3 sturgeon will be stunned, injured or killed due to exposure to a detonation. It is difficult to estimate what portion of these sturgeon will be shortnose and what portion will be Atlantics; however, given that Atlantic sturgeon are more likely to be present in the Marcus Hook area in the winter than shortnose, we expect that no more than 1 of the sturgeon exposed to the detonation will be a shortnose sturgeon and the other two will be subadult or juvenile Atlantic sturgeon.

After blasting is completed, mechanical dredging will be used to remove 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 but 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. Due to the relatively low level of risk that an individual sturgeon would be captured in the slow moving dredge bucket, no more than 1 shortnose sturgeon and no more than 1 Atlantic sturgeon is likely to be captured when mechanical dredging is used. 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, 1 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, blasting and subsequent removal of debris with a mechanical dredge is likely to result in injury or mortality to no more than 2 Atlantic sturgeon and 1 shortnose sturgeon via exposure to the sound and pressure of detonations, and the capture and associated injury or mortality of no more than 1 shortnose sturgeon and 1 Atlantic sturgeon in mechanical dredges. The affected shortnose sturgeon could be a juvenile or adult. Affected Atlantic sturgeon could be YOY, juveniles or subadults. Based on the mixed stock analysis, it is likely that the affected 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.

7.5 Maintenance Dredging

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 10 years of maintenance dredging. The ACOE 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. As explained above, NMFS has estimated an entrainment rate for sea turtles in hopper dredges operating in Reaches D and E of the Philadelphia to the Sea project as 1 sea turtle per every 450,000 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, approximately 1 sea turtle is likely to be entrained for each 450,000 cy of material removed. Over the 10 year maintenance cycle, approximately 4,720,000 cy of material will be removed from the Bay. No more than 11 sea turtles are likely to be killed over the 10 year maintenance cycle, with no more than 1 being a Kemp's ridley and the remainder being loggerheads. Also 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.

Maintenance dredging will also occur in the river. The ACOE has indicated that annually on average, approximately 3,845,000 cy of material will be removed from the river (reaches AA, A, B and C), typically occurring over a two month period between August and December. The ACOE has also indicated that a cutterhead dredge will be used for maintenance dredging activities. As explained above, NMFS has calculated an entrainment rate of 1 shortnose sturgeon and 1 Atlantic sturgeon for every cutterhead dredge event in the river. As such, no more than 1 shortnose sturgeon and no more than 1 Atlantic sturgeon are likely to be killed during each year of maintenance dredging. Based on the mixed stock analysis, it is likely that the affected 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.

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, NMFS anticipates 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 (ACOE 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. The ACOE 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 – December and is therefore unlikely to 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. The preferred forage item in the Delaware River is the Asiatic river clam (*Corbicula manilensis*). 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 ACOE 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 (ACOE 2000, NMFS 1996). The likelihood that 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, sturgeon in the Delaware River primarily forage on the Asiatic river clam. 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 (ACOE 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. However, 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.

NMFS anticipates 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 boat 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 boat. This number underestimates the actual number of boat strikes that occur since not every boat 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 boat. It should be noted, however, that it is not known whether all boat 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 ship 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 have 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 ship 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.

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.

7.8 Effects of Deepening on Substrate/Habitat Type

During the consultation process, NMFS 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, the ACOE 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). The ACOE 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. ACOE 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 the ACOE conducted sediment sampling both before and after deepening occurred in Reach B (ACOE 2012). These reports confirmed that sediment type was unchanged after deepening.

Based on the information provided by ACOE 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 RM 50, with higher salinities near the axis of the bay, and lower salinities on the east and west sides. Upstream of Artificial Island at RM 50, 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 RM 90 in late summer 2005, and at or below RM 40 during multiple high-flow periods in 2006, a range that exceeds 50 miles 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 RM 71, 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 (RM 81) with the minimum in April (RM 61), 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 twenty-mile long zone between RM 61 and RM 81 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 10 miles in a day due to semi-diurnal tides, and by more than 20 miles over periods ranging from a day to weeks or months due to storm and seasonal effects on freshwater inflows.

Figure 4 AND 5

7.9.2 Projected Changes in Salinity

The ACOE 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, the ACOE 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 ACOE 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 30 mile zone of the estuary, moved upstream an average of from 0.0 to 1.0 miles 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.

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 longterm 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 can 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 28ºC (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.

The ACOE 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 areas at Kelly Island and 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 Kelly Island and 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 in those reaches has been designed to minimize the potential for disruption of spawning adults or effects to early life stages. All work in these reaches will occur between August and February; spawning occurs in April and May. 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 2013 and 2015, dredging will be ongoing in Reach D and E, respectively, 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 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 (ACOE 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 Increased Use of Channel by Vessels

During the consultation process, we requested information from ACOE as to whether there would be any expected port expansion resulting from the proposed deepening. The ACOE 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 ACOE and NMFS 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 NMFS by the ACOE 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, the ACOE 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 effects[19]. The activities discussed in the Cumulative Effects section of the 2011 EA developed for the deepening project – the Paulsboro Marine Terminal and the Southport

[19] 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."

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. The ACOE 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 the ACOE 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 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 ACOE 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 ACOE 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. Permitees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through the SPDES permits. However, this Opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the status of the species/environmental baseline section.

9.0 INTEGRATION AND SYNTHESIS OF EFFECTS

In the effects analysis outlined above, NMFS 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; (3) physical alteration of the action area including disruption of benthic communities, changes in substrate type and changes in salinity in the action area. In addition to these categories of effects, NMFS 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, exposure to blasting at Marcus Hook, and capture during mechanical dredging. 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 shortnose sturgeon. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Below, for the listed species that may be affected by the proposed action, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then considers whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal Endangered Species Act.

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, add 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, we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. NMFS also has no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the 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, these instances are rare and involve 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, NMFS expects that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

We have estimated that the ongoing deepening will result in the mortality of five shortnose sturgeon during the initial construction period, inclusive of two shortnose sturgeon during blasting and subsequent debris removal with a mechanical dredge, and ten mortalities during the 10-year maintenance phase. We expect that there will be no more than one mortality per year, except during the winter when blasting occurs when we expect two mortalities, one due to exposure to blasting and one due to capture in the mechanical dredge bucket. 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.

The number of shortnose sturgeon that are likely to die as a result of the ongoing deepening project and 10 years of maintenance (15), 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 15 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 0.13%). The effect of this loss is also lessened as it will be experienced slowly over time, with the death of an average of one 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 ½ 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 15 shortnose sturgeon over a 15-year period at a rate of approximately one 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 the action will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Delaware River. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is approximately 0.13% 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 15 shortnose sturgeon over a 15-year period resulting from the ongoing deepening of the Delaware River and 10-years of maintenance, 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 15 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 certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, NMFS has determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild. Here, NMFS considers the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in a small reduction in the number of shortnose sturgeon in the Delaware River and since it will not affect the overall distribution of shortnose sturgeon other than to cause minor temporary adjustments in movements in the action area. The proposed action will not utilize shortnose sturgeon for recreational, scientific or commercial purposes or affect the adequacy of existing regulatory mechanisms to protect this species. The proposed action is likely to result in the mortality of up to 15 shortnose sturgeon; however, over the 15-year period considered here, the loss of these individuals and what would have been their progeny is not expected to affect the persistence of the Delaware River population of shortnose sturgeon or the species as a whole. The loss of these individuals will not change the status or trend of the Delaware River population, which is stable at high numbers. As it will not affect the status or trend of this population, it will not affect the status or trend of the species as a whole. As the reduction in numbers and future reproduction is very small, this loss would not result in an appreciable reduction in the likelihood of improvement in the status of shortnose sturgeon throughout their range. The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction since the action will cause the mortality of only a small percentage of the shortnose sturgeon in the Delaware River and an even smaller percentage of the species as a whole and these mortalities are not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual shortnose sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact shortnose sturgeon in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action, resulting in the mortality of no more than 15 shortnose sturgeon over the 15-year period considered here is not likely to appreciably reduce the survival and recovery of this species.

9.2 Atlantic sturgeon

As explained above, the proposed action is likely to result in the mortality of a total of six Atlantic sturgeon from the Gulf of Maine, New York Bight, Chesapeake Bay and South Atlantic DPSs during the initial construction period, inclusive of the mortality of three Atlantic sturgeon during blasting and subsequent debris removal with a mechanical dredge, and an additional ten total during ten years of maintenance dredging. We expect that there will be no more than one mortality per year, except during the winter when blasting occurs when we expect three mortalities, two due to exposure to blasting and one due to capture in the mechanical dredge bucket. We expect that the Atlantic sturgeon killed will be YOY, juveniles or subadults. No mortality of any adults is anticipated. All other effects to Atlantic sturgeon, including effects to habitat and prey due to dredging and dredge disposal, will be insignificant and discountable.

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, 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 nine of the Atlantic sturgeon will originate from the New York Bight DPS, three from the Chesapeake Bay DPS, three 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.

9.2.2 Gulf of Maine DPS

Individuals originating from the GOM DPS are likely to occur in the action area. The GOM DPS has been listed as threatened. While Atlantic sturgeon occur in several rivers in the GOM DPS, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available. We have estimated, based on fishery-dependent data, that there are approximately 215 mature adults in the GOM DPS, at least 645 subadults and additional numbers of juveniles (which remain in their natal river and would not be present in the action area). We expect that 7% of the Atlantic sturgeon in the action area will originate from the GOM DPS.

Most of these fish are expected to be subadults, with few adults from the GOM DPS expected to be present in the Delaware River. GOM origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. While there are some indications that the status of the GOM DPS may be improving, there is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

We anticipate the mortality of 16 Atlantic sturgeon over the 15 year period considered here, with one likely to originate from the GOM DPS. Because we do not anticipate the mortality of any adults, we consider here the effects to the GOM DPS from the loss of one subadult (>500mm TL <1,500 mm TL) over the 15 year time period.

The death of one subadult Atlantic sturgeon from the GOM DPS over a 15-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.16% of the population, just considering the minimum estimated number of subadults). While the death of one subadult Atlantic sturgeon will reduce the number of GOM DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[20] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (approximately 0.23%).

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

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

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

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the Delaware River that may be used by GOM DPS subadults or adults. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the ensonified area.

Based on the information provided above, the death of no more than one GOM DPS Atlantic sturgeon over the 15 year period when deepening and maintenance will occur, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one subadult GOM DPS Atlantic sturgeon over a 5-year period represents an extremely small percentage of the species as a whole; (2) the death of one subadult GOM DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of this subadult GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of this subadult GOM DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of GOM DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging GOM DPS Atlantic sturgeon.

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

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

Despite the threats faced by individual GOM DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact Atlantic sturgeon in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action, resulting in the mortality of one subadult GOM DPS Atlantic sturgeon, is not likely to appreciably reduce the survival and recovery of this species.

9.2.3 New York Bight DPS

Individuals originating from the NYB DPS are likely to occur in the action area. The NYB DPS has been listed as endangered. While Atlantic sturgeon occur in several rivers in the NYB DPS, recent spawning has only been documented in the Delaware and Hudson rivers. Kahnle *et al.* (2007) estimated that there is a mean annual total mature adult population of 863 Hudson River Atlantic sturgeon. Using fishery-dependent data we have estimated that there are 88 Delaware River origin adults; combined, we estimate a total adult population of 951 in the New York Bight DPS. We have also estimated that there are at least a mean annual of 2,853 subadults and additional numbers of juveniles resulting from continuing annual spawning in the Delaware and Hudson rivers. We expect that 58% of the Atlantic sturgeon in the action area will originate from the NYB DPS. NYB DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the Hudson or Delaware River spawning populations or for the DPS as a whole.

We have estimated that the proposed deepening and 10 years of maintenance will result in the mortality of 16 Atlantic sturgeon, with nine originating from the NYB DPS. No mortality of adults is anticipated; thus, there will be no loss of Delaware or Hudson River origin adults. We do not anticipate the mortality of any eggs or larvae. Here, we consider the effects of the mortality of nine

YOY, juvenile, or subadult NYB DPS Atlantic sturgeon over the 15 year time period. Because YOY and juveniles remain in their natal river, any YOY or juveniles killed would be Delaware River origin. Any New York Bight DPS subadults could originate from the Delaware or Hudson river. 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. Given the sizes of the two populations, the worst case scenario is that all nine NYB fish that are killed are Delaware River fish; however, that appears to be unlikely. Of the 11 fish captured in the Delaware 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 compostion of New York Bight fish is approximately 2/3 Delaware and 1/3 Hudson. Thus, of the nine NYB Atlantic sturgeon likely to be killed, six are likely to originate from the Delaware River and three from the Hudson River.

There are an estimated 88 adult Atlantic sturgeon in the Delaware River population and at least 264 subadults and an unknown additional number of juveniles. Some Delaware River fish have a unique genetic haplotype (the A5 haplotype); however, whether there is any evolutionary significance or fitness benefit provided by this genetic makeup is unknown. Genetic evidence indicates that while spawning continued to occur in the Delaware River and in some cases Delaware River origin fish can be distinguished genetically from Hudson River origin fish, there is free interchange between the two rivers. This relationship is recognized by the listing of the New York Bight DPS as a whole and not separate listings of a theoretical Hudson River DPS and Delaware River DPS. Thus, while we can consider the loss of Delaware River fish on the Delaware River population and the loss of Hudson River fish on the Hudson River population, it is more appropriate, because of the interchange of individuals between these two populations, to consider the effects of these mortalities on the New York Bight DPS as a whole.

The mortality of nine juvenile or subadult Atlantic sturgeon from the NYB DPS over a 15-year period represents a very small percentage of the YOY, juvenile and subadult population (*i.e.*, approximately 0.3% of the population, just considering the minimum estimated number of subadults; the percentage would be much less if the number of YOY and juveniles was considered). While the death of nine juvenile or subadult Atlantic sturgeon will reduce the number of NYB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the juvenile and subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting these nine fish to adult equivalents[21] (assuming the worst case that they were all subadults; using a conversion rate of 0.48 considering the adult equivalent), and assuming no growth in the adult population, these nine mortalities represent an extremely small percentage of the adult population (approximately 0.45%). The effect of this loss is even smaller when considering that these mortalities will occur over a 15 year period, with no more than three occurring in any one year. When considered on an annual basis this loss of 1-3 Atlantic sturgeon per year, even assuming the worst case that all mortalities are subadults, the annual loss is equivalent to 0.04-0.1%

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

of the annual subadult population and, using the adult equivalent conversion, 0.05-0.15% of the mean annual adult population.

Because there will be no loss of adults, the reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individual future spawners. The loss of nine YOY, juveniles or subadults would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The proposed action will also not affect the spawning grounds within the Hudson River where most NYB DPS fish spawn. 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. We have also determined that dredging will not result in any delay or disruption in any normal behavior including movements of adults from the ocean to the in-river spawning grounds. There will be no effects to spawning adults and therefore no reduction in individual fitness or any future reduction in spawning by these individuals.

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Delaware River. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon.

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

Based on the information provided above, the death of up to nine NYB DPS Atlantic sturgeon over the 15 year period considered here, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of nine YOY, juvenile or subadult NYB DPS Atlantic sturgeon over a 15-year period represents an extremely small percentage of the species as a whole; (2) the death of two juvenile or subadult NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these juvenile or subadult NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these juvenile or subadult NYB

DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of NYB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging NYB DPS Atlantic sturgeon.

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

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

Despite the threats faced by individual NYB DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact Atlantic sturgeon in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action, resulting in the mortality of up to nine YOY, juvenile or subadult NYB DPS Atlantic sturgeon over a 15 year period, 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. While Atlantic sturgeon occur in several rivers in the CB DPS, recent spawning has only been documented in the James River. Using fishery-dependent data, we have estimated that there are 273 adults in the James River population, 819 subadults and additional juveniles (which remain in the James River). Because the James River is the only river in this DPS known to support spawning, this is also an estimate of the total number of adults and subadults in the Chesapeake Bay DPS. We expect that 17% of the 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. Chesapeake Bay DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the James River spawning population or for the DPS as a whole.

We anticipate the mortality of 16 Atlantic sturgeon over the 15 year period considered here, with three likely to originate from the CB DPS. Because we do not anticipate the mortality of any adults, we consider here the effects to the CB DPS from the loss of three subadults (>500mm TL <1,500 mm TL) over the 15 year time period.

The death of three subadult Atlantic sturgeon from the CB DPS over a 15-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.4% of the population, just considering the minimum estimated number of subadults). While the death of three subadult Atlantic sturgeon will reduce the number of CB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the subadult population and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[22] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (approximately 0.5%). On an annual basis, there will be one mortality of a Chesapeake Bay DPS fish in each of three years. When this loss is considered this way, the annual loss is equivalent to 0.1% of the annual subadult population and, using the adult equivalent conversion, 0.18% of the mean annual adult population.

The reproductive potential of the CB DPS will not be affected in any way other than through a

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

reduction in numbers of individuals. The loss of three 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. Reproductive potential of other captured or injured individuals is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

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

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the Delaware River that may be used by CB DPS subadults or adults. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the immediate area where dredging is occuring.

Based on the information provided above, the death of no more than three CB DPS Atlantic sturgeon over a 15-year period resulting from the proposed deepening and ten years maintenance will not appreciably reduce the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of three subadult CB DPS Atlantic sturgeon over a 15-year period represents an extremely small percentage of the species as a whole; (2) the death of three subadult CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these subadult CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult CB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of CB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging CB DPS Atlantic sturgeon.

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

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

Despite the threats faced by individual CB DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact Atlantic sturgeon in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action, resulting in the mortality of three subadult CB DPS Atlantic sturgeon, 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. The SA DPS consists of Atlantic sturgeon origingating from at least six rivers where spawning is still thought to occur. Currently, there are an estimated 343 spawning adults in the Altamaha and there are estimated to be less than 300 spawning adults (total of both sexes) in each of the other five river systems where spawning occurs. Adding these estimates together results in a total mean annual adult population estimated of less than 1,843 mature adults. Our fishery dependent estimate is 324. This is likely an underestimate of the total number of adults in the SA DPS because genetic analysis of individuals observed through the NEFOP program indicate that only individuals from the Savannah and Ogeechee are being captured in Northeast fisheries considered in the NEFSC bycatch report from which these estimates were derived. Because of this, it is difficult to compare these two estimates. It may be reasonable to consider the estimate of 324 adults to be an estimate of the number of adults in the Savannah and Ogeechee rivers only; this results in a population estimate for adults in the three major rivers of 667. Using these estimates of adults, there are an estimated 2,001-5,529 subadults.

We expect that 17% of the 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. South Atlantic DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for any of the spawning populations or for the DPS as a whole.

We anticipate the mortality of 16 Atlantic sturgeon over the 15 year period considered here, with three likely to originate from the SA DPS. Because we do not anticipate the mortality of any adults, we consider here the effects to the SA DPS from the loss of three subadults (>500mm TL <1,500 mm TL) over the 15 year time period.

The death of three subadult Atlantic sturgeon from the SA DPS over a 15-year period represents a very small percentage of the subadult population (*i.e.*, approximately 0.26% of the population, just considering the minimum estimated number of subadults). While the death of three subadult Atlantic sturgeon 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 subadult population (0.05-0.26%) and an even smaller percentage of the overall population of the DPS (juveniles, subadults and adults combined). Even when converting this fish to an adult equivalent[23] (using a conversion rate of 0.48), and assuming no growth in the adult population, this mortality represent a very small percentage of the adult population (approximately 0.08-0.2%). On an annual basis, there will be one mortality of a South Atlantic DPS fish in each of three years. When this loss is considered this way, the annual loss is equivalent to 0.02-0.05% of the annual subadult population and, using the adult equivalent conversion, 0.03-0.08% of the mean annual adult

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

population.

The reproductive potential of the SA DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of three 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. 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; there will also be no reduction in individual fitness or any future reduction in numbers of individuals.

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

The proposed action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the Delaware River that may be used by SA DPS subadults or adults. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the immediate area where dredging is occuring.

Based on the information provided above, the death of no more than three SA DPS Atlantic sturgeon over a 15-year period resulting from the proposed deepening and ten years maintenance 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, including reproduction, sustenance, and shelter. This is the case because: (1) the death of three subadult SA DPS Atlantic sturgeon over a 15-year period represents an extremely small percentage of the species as a whole; (2) the death of three subadult SA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these subadult 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 this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of 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 no effect on the ability of SA DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging SA DPS Atlantic sturgeon.

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

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

Despite the threats faced by individual SA DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact Atlantic sturgeon in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action, resulting in the mortality of three subadult SA DPS Atlantic sturgeon over a 15 year period, 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 take anticipated (16 over a 15 year period) and the expected rarity of Carolina fish in the action area, it is extremely unlikely that any of the 16 fish that will be killed during the deepening of 10 years of subsequent maintenance will originate from the Carolina DPS. 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. 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 450,000 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 ACOE 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 11 sea turtles likely to be entrained during the initial deepening, no more than 1 is likely to be a Kemp's ridley, with the remainder loggerheads. Similarly, of the 11 sea turtles likely to be entrained during 10 years of maintenance dredging in the Bay, no more than 1 is likely to be a Kemp's ridley, with the remainder loggerheads. As such, the proposed action is likely to result in the entrainment and mortality of no more than 2 Kemp's ridleys and the remainder loggerheads. No entrainment of Kemp's ridley sea turtles is anticipated if a cutterhead dredge is used for deepening in Reach D.

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 provides 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 does 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. NMFS also takes 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 expect this increasing trend to continue over the time period considered in this Opinion.

The mortality of 2 Kemp's ridleys over a 15 year time period represents a very small percentage of the Kemp's ridleys worldwide. Even taking into account just nesting females, the death of 2 Kemp's ridley represents less than 0.03% of the population. While the death of 2 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 stable to increasing 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 species' nesting trend is increasing; (2) the death of 2 Kemp's ridleys represents an extremely small percentage of the species as a whole; (3) the death of 2 Kemp's ridleys will not change the status or trends of the species as a whole; (4) the loss of these Kemp's ridleys is not likely to have an effect on the levels of genetic heterogeneity in the population; (5) 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 certain instances an action that does not appreciably reduce the likelihood of a species survival (persistence) may affect its likelihood of recovery or the rate at which recovery is expected to occur.

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

The proposed action is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of Kemp's ridley sea turtles in any geographic area and since it will not affect the overall distribution of Kemp's ridley sea turtles other than to cause temporary delays in migratory movements. The proposed action will not utilize Kemp's ridley sea turtles for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect this species or affect its continued existence. The proposed action is likely to result in the mortality of up to two Kemp's ridleys; however, as explained above, the loss of these individuals and what would have been their progeny is not expected to affect the persistence of Kemp's ridleys. As the reduction in numbers and future reproduction is very small, the loss of these individuals will not change the status or trend of Kemp's ridleys, which is stable to increasing. The effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction since the action will cause the mortality of only a very small percentage of the species as a whole and these mortalities are not expected to result in the reduction of overall reproductive fitness for the species as a whole. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that Kemp's ridleys can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual Kemp's ridley sea turtles inside and outside of the action area, the proposed action 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 action. While NMFS is not able to predict with precision how climate change will continue to impact Kemp's ridley sea turtles in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action, resulting in the mortality of no more than 2 Kemp's ridleys 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. 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 450,000 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 ACOE 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 11 sea turtles likely to be entrained during the initial deepening, 10 are likely to be loggerheads. Similarly, of the 11 sea turtles likely to be entrained during 10 years of maintenance dredging in the Bay, 10 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 20 loggerheads over the 15 year time period considered here; with an average mortality rate of 1-2 loggerheads per year. The lethal removal of up to 20 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 percent from the Yucatan subpopulation, and 2 percent 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 20 loggerheads likely to be killed, 16 are expected to be from the PFRU, with 3 from the NRU and 1 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 16 loggerheads over a 15-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 1 individual would represent approximately 0.1% of the population. Similarly, the loss of 3 loggerheads 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 1 individual would represent approximately 0.3% of the population. The loss of 1 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 15 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 20 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 20 loggerheads represents an extremely small percentage of the species as a whole; (3) the death of 20 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; (5) 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, (6) the action will have no effect on the ability of loggerheads to shelter and only an insignificant effect on individual foraging loggerheads.

In certain 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, NMFS has determined that the proposed action will not appreciably reduce the likelihood that loggerheads will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate.

Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action will not appreciably reduce the likelihood of survival of the loggerhead sea turtle species. Also, it is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of loggerheads in any geographic area and since it will not affect the overall distribution of loggerheads other than to cause minor temporary adjustments in movements in the action area. The proposed action will not utilize loggerheads for recreational, scientific or commercial purposes, affect the adequacy of existing regulatory mechanisms to protect loggerhead sea turtles, or affect their continued existence. As explained above, the proposed action is likely to result in the mortality of up to 20 loggerheads between now and 2027; however, as explained above, the loss of these individuals over this time period is not expected to affect the persistence of loggerhead sea turtles. In summary, the effects of the proposed action will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the action will not prevent the species from growing in a way that leads to recovery and the action will not change the rate at which recovery can occur. This is the case because while the action 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 action is 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 action will not appreciably reduce the likelihood that loggerhead sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual loggerhead sea turtles inside and outside of the action area, the proposed action 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 action. While NMFS is not able to predict with precision how climate change will continue to impact loggerhead sea turtles in the action area or how the species will adapt to climate-change related environmental impacts, we have considered the effects of the proposed action 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 action is 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 NMFS jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is NMFS' biological opinion that the proposed action may adversely affect but is not likely to jeopardize the continued existence of the shortnose sturgeon, any DPS of Atlantic sturgeon, Kemp's ridley and loggerhead sea turtles and is not likely to adversely affect 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 intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by ACOE so that they become binding conditions for the exemption in section 7(o)(2) to apply. ACOE has a continuing duty to regulate the activity covered by this Incidental Take Statement. If ACOE (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, ACOE 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 dredging project has the potential to directly affect loggerhead and Kemp's ridlely sea turtles, shortnose sturgeon, and individuals from the New York Bight, Gulf of Maine, Chesapeake Bay and South Atlantic DPSs of Atlantic sturgeon to become entrained in the dredge. These interactions are likely to cause mortality. Shortnose sturgeon and individuals from the New York Bight, Gulf of Maine, Chesapeake Bay and South Atlantic DPSs of Atlantic sturgeon may be exposed to noise and pressure during blasting and may be captured 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 the 10 years of planned maintenance dredging. This level of take is expected to occur over the entire 15 year period and is not likely to jeopardize the continued existence of listed species.

This ITS exempts the following lethal take:

- 20 Northwest Atlantic DPS loggerhead sea turtles;
- 2 Kemp's ridley sea turtles;
- 15 shortnose sturgeon;
- 9 New York Bight DPS Atlantic sturgeon;
- 3 Chesapeake Bay DPS Atlantic sturgeon;
- 3 South Atlantic DPS Atlantic sturgeon; and,
- 1 Gulf of Maine DPS Atlantic sturgeon.

The level of take of loggerhead sea turtles would be less if a cutterhead dredge was used to deepen Reach D. In that case, the total level of lethal take would be 18 instead of 20. During the maintenance dredging period, we anticipate a total entrainment level of 11 loggerheads and one Kemp's ridley; the other turtles are expected to be entrained during the initial construction period. We expect that five of the shortnose sturgeon will be killed during the initial construction period, inclusive of two killed during blasting and associated mechanical dredging, and that the remaining ten shortnose sturgeon will be killed during the 10-year maintenance period at an average rate of one shortnose sturgeon per year. Shortnose sturgeon that will be killed will be subadults or adults. We expect that six of the Atlantic sturgeon will be killed during the initial construction period, inclusive of three killed during blasting and associated mechanical dredging, and that the remaining ten Atlantic sturgeon will be killed during the 10-year maintenance period at an average rate of one Atlantic sturgeon per year. The nine New York Bight DPS Atlantic sturgeon killed will consist of YOY, juveniles and subadults. The three Chesapeake Bay, three South Atlantic, and one Gulf of Maine DPS Atlantic sturgeon will be subadults. No take of any adult Atlantic sturgeon is anticipated.

11.2 Reasonable and prudent measures

NMFS believes the following reasonable and prudent measures 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. NMFS 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 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. The ACOE 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. The ACOE 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. The ACOE 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. NMFS must be contacted prior to the commencement of blasting and again upon completion

of the blasting and subsequent mechanical dredging activity.

9. The ACOE must utilize a procedure designed in association with NMFS to minimize the potential for detonations to occur when shortnose or Atlantic sturgeon are within 500 feet of the blast location.

10. The ACOE must monitor the blasting site for the presence of acoustically tagged sturgeon and monitor their movements during the blasting period.

11. Blasting must be conducted in a manner designed to minimize the potential for fish kills.

12. Acoustic measurement of the first three detonations must be conducted to confirm the underwater pressure levels estimated by ACOE.

13. The ACOE must design and implement a monitoring plan to ensure that any sturgeon killed during blasting are recorded.

14. 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.

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

RPMs for all aspects of the project:

16. The ACOE must conduct sediment sampling following the completion of dredging 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, ACOE must work with us to develop an appropriate restoration method to restore substrate types in these reaches.
17. The ACOE must develop 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 NMFS.

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 NMFS.

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

21. Any dead sea turtles must be held until proper disposal procedures can be discussed with NMFS. Turtles must be held in cold storage.

22. All sturgeon and turtle captures, injuries or mortalities associated with the deepening and maintenance activities and any sturgeon and sea turtle sightings in the action area must be reported to NMFS within 24 hours.

11.3 Terms and conditions

In order to be exempt from prohibitions of section 9 of the ESA, the ACOE 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, the ACOE must contact NMFS (Julie Crocker: by email (julie.crocker@noaa.gov) or phone (978) 282-8480 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 NMFS of the commencement and cessation of dredging activities and to give NMFS an opportunity to provide ACOE with any updated contact information or reporting forms.

2. To implement RPM #2, for cutterhead dredging, the ACOE 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. The ACOE 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, the ACOE 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 ACOE 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 for the observation of at least 50% of the dredge loads (e.g., 12 hours on, 12 hours off). The ACOE must ensure that ACOE 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 A). No observers can be deployed to the dredge site until ACOE has written confirmation from NMFS that they have met the qualifications to be a "NMFS-approved observer" as outlined in Appendix A. If substitute observers are required during dredging operations, ACOE must ensure that NMFS approval is obtain 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). ACOE must ensure that ACOE 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 A). No observers can be deployed to the dredge site until ACOE has written confirmation from NMFS that they have met the qualifications to be a "NMFS-approved observer" as outlined in Appendix A. If substitute observers are required during dredging operations, ACOE must ensure that NMFS approval is obtain before those observers are deployed on dredges.

7. To implement RPM #5, the ACOE shall require of the dredge operator that, when the observer is off watch, the cage shall not be opened unless it is clogged. The ACOE 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, the ACOE 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 A.

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 B).

11. To implement RPM #8, each winter that blasting is undertaken, the ACOE must inform NMFS 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 RPM #9, at least 45 days prior to the commencement of blasting, the ACOE must submit to NMFS a plan outlining the measures the ACOE will take to ensure that no shortnose or Atlantic sturgeon are present within 500 feet of the detonation site. This 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. This plan must be developed with input from shortnose and Atlantic sturgeon experts. The plan must also contain measures to ensure that the 500-foot radius surrounding the detonation site is clear within 30 minutes of the commencement of the detonation.

13. To implement RPM#9, the ACOE must not commence blasting operations prior to receiving confirmation from NMFS that the blasting plan is acceptable.

14. To implement RPM#10, the ACOE must work with Atlantic and shortnose sturgeon researchers to monitor the movement of acoustically tagged sturgeon during the blasting operations. The monitoring plan must be submitted to NMFS 45 days prior to the commencement of blasting.

15. To implement RPM#11, the ACOE must 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.

16. To implement RPM #12, 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 ACOE (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 NMFS prior to any subsequent blasting.

17. To implement RPM#13, at least 45 days prior to the commencement of blasting, the ACOE will submit to NMFS a plan outlining the measures the ACOE must take to monitor for injured 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 fish.

18. To implement RPM#14, for mechanical dredging following blasting operations, the ACOE 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 ACOE has written confirmation from NMFS that they have met the qualifications to be a "NMFS-approved observer" as outlined in Appendix A. If substitute observers are required during dredging operations, ACOE must ensure that NMFS approval is obtained before those observers are deployed on dredges.

19. To implement RPM #15, 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 #16, the ACOE must conduct sediment sampling following the completion of dredging 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, ACOE 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 to document any unanticipated loss of hard bottom habitat in the area. Should it be found that substrate type has changed as a result of the deepening, ACOE must work with us to develop an appropriate restoration method to restore substrate types in this reach.

21. To implement RPM#17, the ACOE must work with Atlantic and shortnose sturgeon researchers to monitor the movement of acoustically tagged sturgeon during dredging operations. The monitoring program must be designed to 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. The monitoring plan must be submitted to NMFS 45 days prior to the commencement of dredging where monitoring will occur. Preliminary reports containing information on the number of tagged sturgeon detected and their movements must be provided to NMFS within 90 days of the completion of dredging. This term and condition does not require ACOE to tag any sturgeon with telemetry tags.

22. To implement RPM #18, the ACOE must ensure that fin clips are taken (according to the procedure outlined in Appendix E) of any sturgeon captured during the project and that the fin clips are sent to NMFS for genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies.

23. 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 NMFS.

24. 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 NMFS. The form included as Appendix F (sturgeon salvage form) must be completed and submitted to NMFS.

25. 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 NMFS.

26. 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 ACOE anticipates that they will not be counted towards the ITS) must be frozen and transported to a nearby stranding or rehabilitation facility for review. ACOE must ensure that the observer submits the incident report for the decomposed turtle part, as well as photographs, to NMFS within 24 hours of the take (see Appendix D) and request concurrence that this take should not be attributed to the Incidental Take Statement. NMFS shall have the final say in determining if the take should count towards the Incidental Take Statement.

27. To implement RPM #22, the ACOE must contact NMFS within 24 hours of any interactions with sturgeon or sea turtles, including non-lethal and lethal takes. NMFS will provide contact information annually when alerted of the start of dredging activity. Until alerted otherwise, the ACOE should contact Julie Crocker: by email (julie.crocker@noaa.gov) or phone (978) 282-8480 or the Section 7 Coordinator by phone (978)281-9328 or fax 978-281-9394). Take information should also be reported by e-mail to: incidental.take@noaa.gov.

28. To implement RPM #22, the ACOE must photograph and measure any sturgeon 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 D) must be completed and submitted to NMFS **within 24 hours** by fax (978-281-9394) or e-mail (incidental.take@noaa.gov).

29. To implement RPM #22, any time a take occurs ACOE must immediately contact NMFS to review the situation. At that time, ACOE must provide NMFS with information on the amount of material dredged thus far and the amount remaining to be dredged during that cycle. Also at that time, ACOE should discuss with NMFS whether any new management measures could be implemented to prevent the total incidental take level from being exceeded and will work with NMFS to determine whether this take represents new information revealing effects of the action that may not have been previously considered.

30. To implement RPM #8, the ACOE must submit a final report summarizing the results of dredging and any takes of listed species to NMFS 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 ACOE 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 ACOE has reviewed the RPMs and Terms and Conditions outlined above and has agreed to implement all of these measures as described herein and in the referenced Appendices. 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 ACOE.

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 ACOE with any updated contact information for NMFS staff. This is only a minor change because it is not expected to result in any delay to the project and will merely involve an occasional telephone call or e-mail between ACOE and NMFS staff.

Several of the RPMs (#2,4, 5 and 14) as well as the implementing Term and Conditions (#2, 3, 5,6,7, and 18) are necessary and appropriate because they require that the ACOE 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 the ACOE 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, is 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 ACOE 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 #15 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 #8-13 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 meters of the detonation site. These conditions are also designed to verify that the sound and pressure levels presented by ACOE and relied on by NMFS in estimating take are valid and that a 500 meter exclusion zone is sufficient. This does not cause more than minor changes because it merely provides additional clarification to the requirement already imposed by the ACOE 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 ACOE 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 #16 and Term and Condition #20 are necessary and appropriate as they will serve to verify the ACOE's determination that deepening 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 ACOE 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 #21 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 ACOE 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 #22-30 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. Theses 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, NMFS recommends that the ACOE consider the following Conservation Recommendations:

(1) To the extent practicable, the ACOE 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. The ACOE 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.

(3) If any lethal take occurs, the ACOE should arrange for contaminant analysis of the specimen. If this recommendation is to be implemented, the fish should be immediately frozen and NMFS should be contacted within 24 hours to provide instructions on shipping and preparation.

(4) The ACOE 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 A, the ACOE should consider using a dredge equipped with the rigid deflector draghead as designed by the ACOE 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) The ACOE 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 the ACOE 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.

MONITORING SPECIFICATIONS FOR 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 ACOE shall require of the dredge operator that, when the observer is off watch, the cage shall not be opened unless it is clogged. The ACOE 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 D) 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 D):

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 D). The photographs and reports should be submitted by email (incidental.take@noaa.gov) or mail (Attn: Section 7 Coodinator, 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 ACOE 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.

APPENDIX B.

MONITORING SPECIFICATIONS FOR MECHANICAL DREDGES

I. EQUIPMENT SPECIFICATIONS

A. Floodlights

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

B. Intervals between dredging

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

II. OBSERVER PROTOCOL

A. Basic Requirement

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

B. Duty Cycle

A NMFS-approved 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 ACOE 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 (Appendix D).

<u>Dead sea turtles</u>
The procedures for handling dead sea turtles and parts are described in Appendix C-II-E.

<u>Live sea turtles</u>
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:

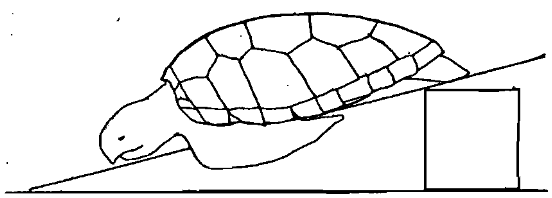
1) Contact the nearest rehabilitation facility to inform them of the incident. If the rehabilitation personnel cannot be reached immediately, please contact NMFS stranding hotline at 978-281-9351 or NMFS Sea Turtle Stranding Coordinator at 978-281-9328.
2) Keep the turtle shaded and moist (e.g., with a water-soaked towel over the eyes, carapace, and flippers), and in a confined location free from potential injury.
3) 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.
4) 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 in Appendix C-II-E, 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/rehabiliton contacts

Sea Turtles in Delaware Bay

< NMFS Stranding Hotline: (978) 281-9351 or NERStranding.staff@noaa.gov

Delaware:

< MERR Institute, Inc.
Nassau, DE
302-228-5029

New Jersey

- Marine Mammal Stranding Center
Brigantine, NJ
609-266-0538

APPENDIX D

ENDANGERED SPECIES OBSERVER FORM
Delaware River Deepening

Daily Report

Date: ___________________________________
Geographic Site:____
Location: Lat/Long ______________________ Vessel Name ______________________________

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 Incident Report of Sea Turtle/ Sturgeon Mortality*)

Comments (type of material, biological specimens, unusual circumstances, etc:)
____
____
____

Observer's Name: ____
Observer's Signature: ____

Species	# of Sightings	# of Animals	Comments

Incident Report of Sea Turtle Take

Species _____________ Date _______________ Time (specimen found) ________________

Geographic Site ____
Location: Lat/Long ____
Vessel Name _________________________ Load # _____________________________
Begin load time _______________________ End load time_________________________
Begin dump time ______________________ End dump time _______________________

Sampling method ____
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)
____
____
____

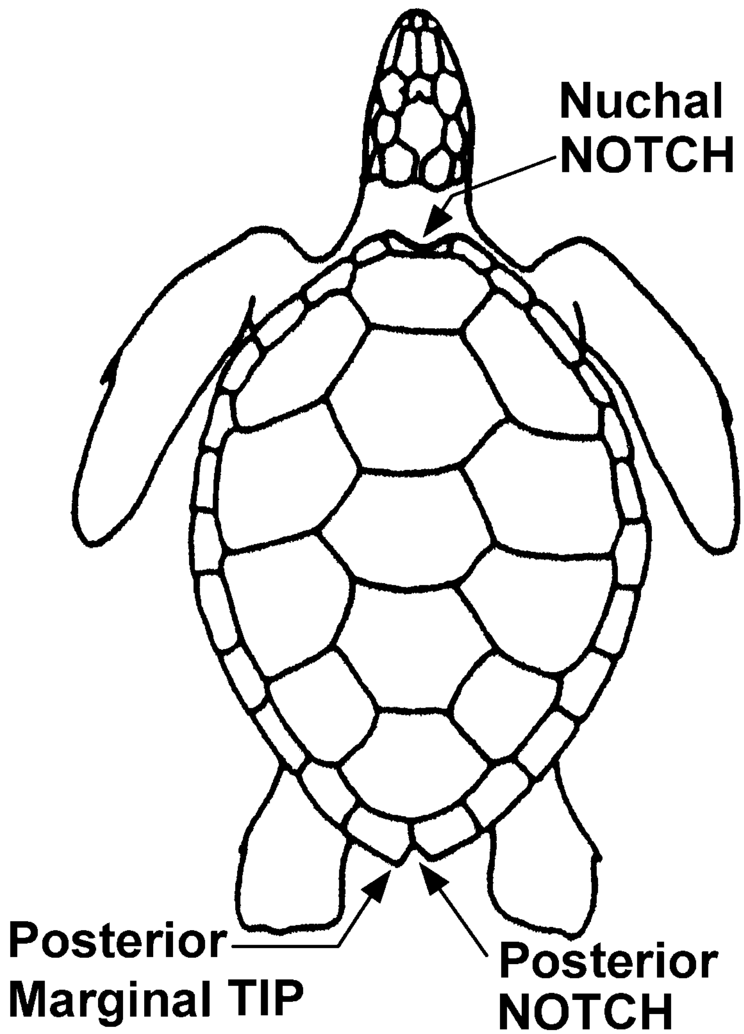
Turtle Decomposed: NO SLIGHTLY MODERATELY SEVERELY

Turtle tagged: YES NO *Please record all tag numbers.* Tag # ______________________
Genetic sample taken: YES NO
Photograph attached: YES NO
(please label *species, date, geographic site* and *vessel name* on back of photograph)

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____
Vessel Name ___________________________ Load # _____________________________
Begin load time _________________________ End load time_________________________
Begin dump time ________________________ End dump time ______________________

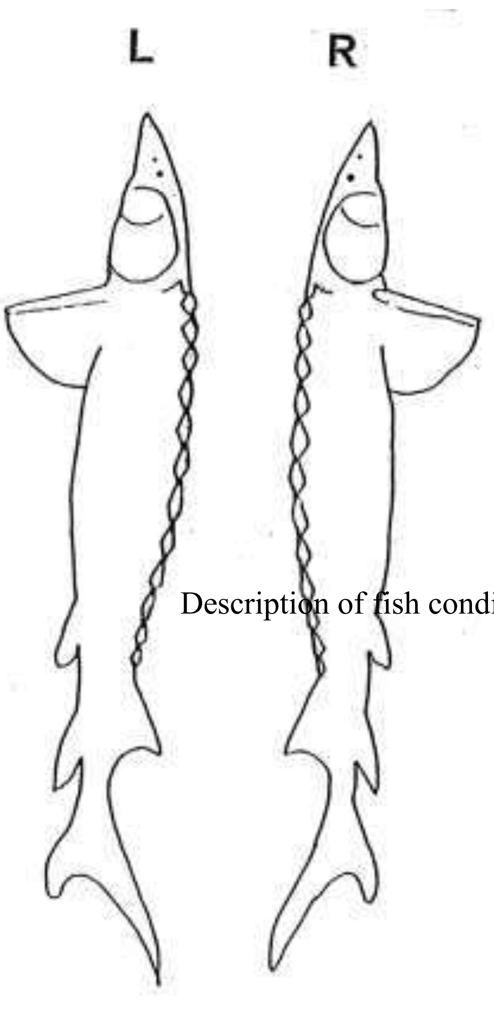
Sampling method ____
Condition of screening ____
Location where specimen
recovered____
____
Draghead deflector used? YES NO Rigid deflector draghead? YES NO
Condition of deflector ____
____
Weather conditions____
____
Water temp: Surface _________________ Below midwater (if known) ________________

Species Information: *(please designate cm/m or inches.)*
Fork length (or total length) ______________________ Weight ______________________

Condition of specimen/description of animal
____
____
____
____

Fish Decomposed: NO SLIGHTLY MODERATELY SEVERELY
Fish tagged: YES / NO *Please record all tag numbers.* Tag # _________________
Genetic sample taken: YES NO
Photograph attached: YES / NO
(please label *species, date, geographic site* and *vessel name* on back of photograph)
Comments/other (include justification on how species was identified)
____
____
Observer's Name ____________________Observer's Signature______________________

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



Description of fish condition:

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:

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

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

STURGEON SALVAGE FORM

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

INVESTIGATORS'S CONTACT INFORMATION
Name: First ______________ Last ______________
Agency Affiliation ______________ Email______________
Address ______________________________
____
Area code/Phone number ______________________________

UNIQUE IDENTIFIER (Assigned by NMFS)

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

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

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

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

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

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

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

Tag #	**Tag Type**	**Location of tag on carcass**

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

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

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

SAMPLES COLLECTED? ☐ **Yes** ☐ **No**

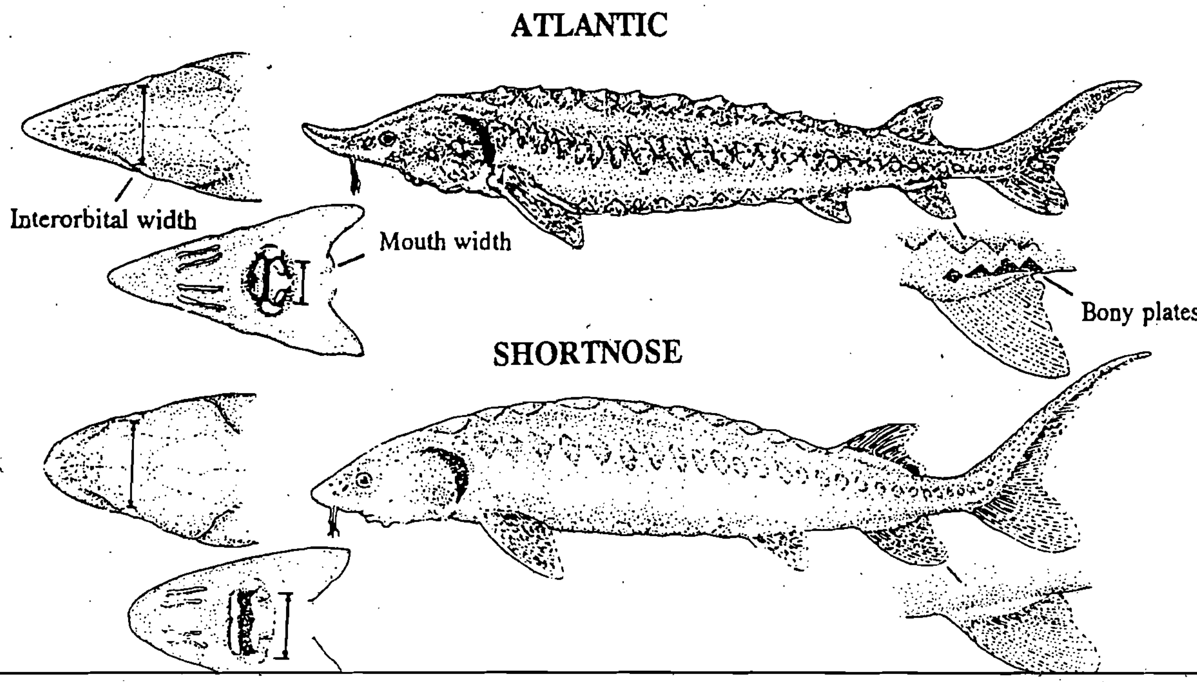
Sample	**How preserved**	**Disposition (person, affiliation, use)**

Comments:
____
____
____

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

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

* From Vecsei and Peterson, 2004



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

____

____

____

____

____

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

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