NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency: Army Corps of Engineers (USACE), Philadelphia District
U.S. Coast Guard (USCG)

Activity Considered: Deepening and Maintenance of the Delaware River Federal Navigation Channel
NER-2018-15005 GARFO-2018-00242

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

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1.0 INTRODUCTION

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of the U.S. Army Corps of Engineers (USACE) ongoing maintenance dredging of the Philadelphia to Trenton Federal Navigation Project (FNP), as well as ongoing deepening and future maintenance dredging of the 45-foot FNP from Philadelphia to the Sea. This Opinion also assesses effects of the beneficial use of dredged material at Oakwood Beach and the Dredged Material Utilization (DMU) study sites (seven Delaware Bay front communities in Delaware, and three in New Jersey), as well as the installation of the Marcus Hook range lights (an interrelated activity proposed by the U.S. Coast Guard). For the Philadelphia to Trenton FNP, this Opinion is based on your August 2014 Biological Assessment (BA) and our 1996 and 2017 Opinions on dredging USACE's Philadelphia District. For the deepening project, this Opinion is based on information you provided, including 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; a plan for the proposed relocation trawl study dated November 2013; a November 27, 2013 submittal to us regarding the Oakwood Beach project, including the November 2013 draft EA; a report on the feasibility of using underwater sound to behaviorally exclude sturgeon from a blasting area dated July 30, 2015, a final sturgeon monitoring and protection plan dated August 25, 2015; the end of season reports (2015-2016, 2016-2017, and 2017-2018) on sturgeon monitoring and relocation during rock removal; as well as our October 25, 1996 Opinion on dredging in USACE's Philadelphia District; a May 25, 1999 supplement to the 1996 Opinion; the February 2, 2001 Opinion on the Delaware River Main Channel Blasting Project; and our July 2009, July 2012, January 2014, November 2015, and November 2017 Opinions on the deepening and maintenance project.

You submitted a draft BA dated June 4, 2018, for the deepening that remains to be completed as well as supplemental analyses and information (dated August 3, 2018, September 18, 2018, and emails from the period June through November 2018) of the effects of the ongoing deepening and future maintenance dredging (Philadelphia to the Sea 45-foot FNPs and the Philadelphia to Trenton FNP). Those analyses, along with scientific papers and other sources of information as cited in the references section also helped form the basis of this Opinion. A complete administrative record of this consultation will be kept at the NMFS Greater Atlantic Regional Fisheries Office.

2.0 PROJECT HISTORY

2.1 ESA Consultation History: Maintenance of the Existing Channel (Philadelphia to the Sea and Philadelphia to Trenton FNPs)

In September 1986, you 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 us with the initiation request. You determined 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, you reinitiated consultation regarding potential impacts associated with dredging projects permitted, funded or conducted by you. 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 you 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. We issued an Opinion on November 26, 1996, which considered effects of all of the above batched projects conducted or authorized by you in the Philadelphia District. The Opinion concluded your 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. This Opinion was amended with a revised ITS on May 25, 1999 and exempted the annual take of up to four shortnose sturgeon and four loggerhead sea turtles or one Kemp’s ridley or one green sea turtle.

2.2 Philadelphia to Trenton Federal navigation project (FNP)

The existing Philadelphia to Trenton Federal Navigation Project (FNP) (Figure 1) was adopted in 1930 (R&H Com Doc 3, 71st Cong., 1st Session) and modified in 1935 (R&H Com Doc 11, 73rd Cong., 1st Session and R&H Com Doc 66, 74th Cong., 1st Session), 1937 (R&H Com Doc 90, 74th Cong., 2nd Session), 1946 (HD 679, 79th Cong., 2nd Session), and 1954 (HD 358, 83rd Cong., 2nd Session). The acts provide for a channel and turning basins in the Delaware River, bank protection, and bridge reconstruction.

The project dimensions for the main navigation channels vary from 35 feet deep and 300 feet wide to 40 feet deep and 400 feet wide. Except for the stretch between Newbold Island and the Trenton Marine Channel, the project has been completed. Deepening the Newbold Island to Trenton Marine Channel from 25 to 35 feet has been deferred, as the City of Trenton has not provided terminal facilities adequate for a 35-foot channel. The remaining authorized portion continues to the upstream limit of the project just below the Penn-Central R.R. Bridge crossing the Delaware River at Trenton. This 12-foot deep channel is currently used for recreation purposes with no commercial port-side facilities existing above the Trenton Marine Channel. In addition, an auxiliary channel and 20-foot deep and 200-foot wide turning basin is authorized on the east side of Burlington Island within the Philadelphia to Trenton FNP, but has not been maintained by the District for more than 40 years. The total length of the Philadelphia to Trenton FNP is 30.36 river miles (RM).

There are two major deep draft Marine Terminals (Port of Bucks County and Tioga Marine Terminal) that operate from within the Philadelphia to Trenton FNP. The Port of Bucks County (Fairless Turning Basin) consists of three portside companies: WM-Grows, Silvi-Bristol and Kinder Morgan. The Tioga Marine Terminal, located in the Port Richmond section of Philadelphia, is a full service deep water port and marine terminal. The Tioga Marine Terminal is also a lay berth site for U.S. Naval Vessels and operates under the Philadelphia Regions Strategic Port Initiative and Marine Transportation Security Act.

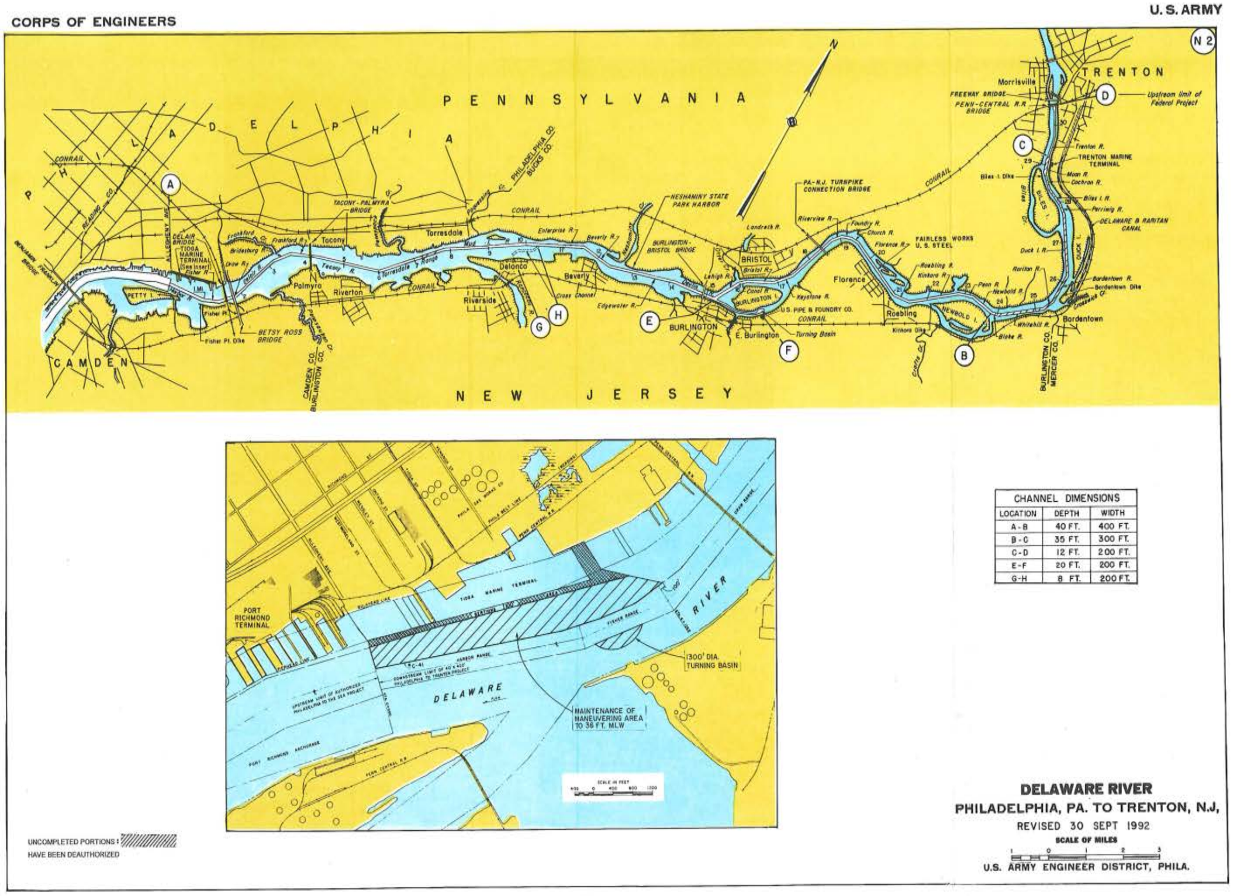

Figure 1. Delaware River, Philadelphia to Trenton Federal Navigation Channel Project.

As detailed above, our 1996 Opinion concluded that your dredging program, including maintenance of the Philadelphia to the Sea and Philadelphia to Trenton Federal navigation projects (FNP), 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's revised ITS (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.

On April 6, 2012, we listed Atlantic sturgeon under the ESA. The listing triggered reinitiation of the 1996 Opinion. Although the 1996 Opinion, with its revised 1999 ITS, covered all maintenance dredging within the District, the only immediate need for dredging involved completion of the deepening and maintenance dredging of the Philadelphia to the Sea FNP. Maintenance dredging within the Philadelphia to Trenton section of the Delaware River occurred once every 2-3 years depending upon available funding and seasonal shoaling. Therefore, you decided to complete reinitiation and a new Opinion only considering the effects on long-term maintenance on the Philadelphia to the Sea and the Philadelphia to Trenton FNPs. However, due to Superstorm Sandy, the District determined that emergency dredging was needed in the Philadelphia to Trenton FNP.

In letters dated April 3, 2013 and July 3, 2013, you requested informal consultation for emergency dredging operations stating that shoaling in the channel was creating unsafe conditions and posed an imminent risk to life and property. Emergency dredging was conducted in the upper reach of the 40-foot channel, Fairless Turning Basin and a section of Duck Island Range (25-foot channel) by Norfolk Dredging Company from 11 October 2013 to 29 November 2013. A pipeline dredge removed 541,381 cubic yards of shoaled material, deposited by Superstorm Sandy storm. The Money Island and Biles Island upland disposal sites were used as placement sites for the dredged material.

At the time of this emergency work, we requested that you initiate formal consultation as soon as practicable after the emergency dredging was completed. You provided a Biological Assessment to us on August 11, 2014, both to complete emergency consultation and to consider the effects of all foreseeable future projects within the Philadelphia to Trenton FNP.

Following the receipt of the 2014 BA, we continued to work together to further define the proposed action and its effects on ESA listed species in order to fully determine the subject action of the subsequent consultation and Opinion. Specifically, our agencies participated in discussions about the timing of maintenance dredging activities and appropriate, practicable time of year windows for completing dredge activities. Our agencies held a joint agency meeting on September 4, 2015 to discuss proposed modifications to the existing environmental windows for the upper Delaware River, Philadelphia to Trenton federal navigation project. You provided a summary of the meeting notes to us on December 22, 2015.

On June 3, 2016, we published two proposed rules (81 FR 35701; 81 FR 36078) to designate critical habitat for the five distinct population segments (DPS) of federally listed Atlantic sturgeon. The proposed rule designating critical habitat for the New York Bight Distinct Population Segment (DPS) of Atlantic sturgeon included portions of the action area considered during our prior discussions on reinitiation. On August 15, 2016, we received your letter requesting conference to assess the potential impacts of dredging, blasting, and placement activities associated with Delaware River channel deepening and maintenance, including the Philadelphia to Trenton FNP, on proposed critical habitat for Atlantic sturgeon (New York Bight DPS). On September 13, 2016, you submitted a revised request for conference, in which you concluded that while the projects are not likely to destroy or adversely modify proposed critical habitat for Atlantic sturgeon, you were still requesting conference to consider the projects' effects.

2.3 Philadelphia to the Sea Federal navigation project (FNP), 40-Foot Channel

The Delaware River Philadelphia to the Sea FNP was authorized by Congress in 1910 and modified in 1930, '35, '38, '45, '54 and '58. This 155.3 km (96.5 mile) long channel was authorized for depths of 37 to 40 feet. In October 2017, you informed us that there will not be any future maintenance dredging of the 40-foot channel, as all reaches have already been deepened to 45 feet, or are in the process of being deepened and will not be dredged to 40 feet again. Below, we offer a brief history of this project and our consultations with you, as they are relevant to the development of the channel deepening and 45-foot maintenance projects discussed below (see section 2.4).

The 40-foot navigation project provided for a channel from deep water in the Delaware Bay (i.e., the point at which the Bay is naturally deep enough to obviate the need for channel dredging) 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. See Figure 2 for a map of the general project location.

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

In August 2012, you requested initiation of formal consultation regarding the effects maintenance of the Philadelphia to the Sea 40-foot channel. You submitted a Biological Assessment to us with a letter dated April 22, 2013. As the ongoing project to deepen the channel from 40 to 45 feet would not be completed until 2017 or 2018 (see Section 2.4 below), this consultation only assessed maintenance dredging to maintain 40-foot navigational clearance. We acknowledged receipt of the BA in a letter dated May 10, 2013, stating that we had until September 8, 2013 to complete a Biological Opinion. The Opinion was signed and sent to you on August 1, 2013.

You sent us a letter dated October 29, 2014, which requested reinitiation of the 2013 Opinion based on an exceedance of take covered in the ITS that exempted the lethal take of one loggerhead

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[1] All depths refer to mean low water.

or Kemps' ridley sea turtle, one shortnose sturgeon, and one Atlantic sturgeon. On May 16, 2014, a juvenile Atlantic sturgeon was killed during maintenance dredging taking place in the Tinicum range of the Delaware River, and another juvenile Atlantic sturgeon was killed on October 24, 2014 in the Fort Mifflin range of the river.

On August 15, 2016, we received your letter requesting conference to assess the potential impacts of dredging, blasting, and placement activities associated with Delaware River channel deepening and maintenance, including the Philadelphia to the Sea FNP, on proposed critical habitat for Atlantic sturgeon. On September 13, 2016, you submitted a revised request for conference, in which you concluded that while the projects are not likely to destroy or adversely modify proposed critical habitat for Atlantic sturgeon, you were still requesting conference to consider the projects' effects on critical habitat.

2.4 Channel Deepening Proposal and Consultation History

In 1983, you were 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 you on the EIS and SEIS in letters dated March 1, 1995, February 14, 1997 and September 29, 1997.

In May 2000, you 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, you 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 your website on December 18, 2008, announcing that you 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. 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.

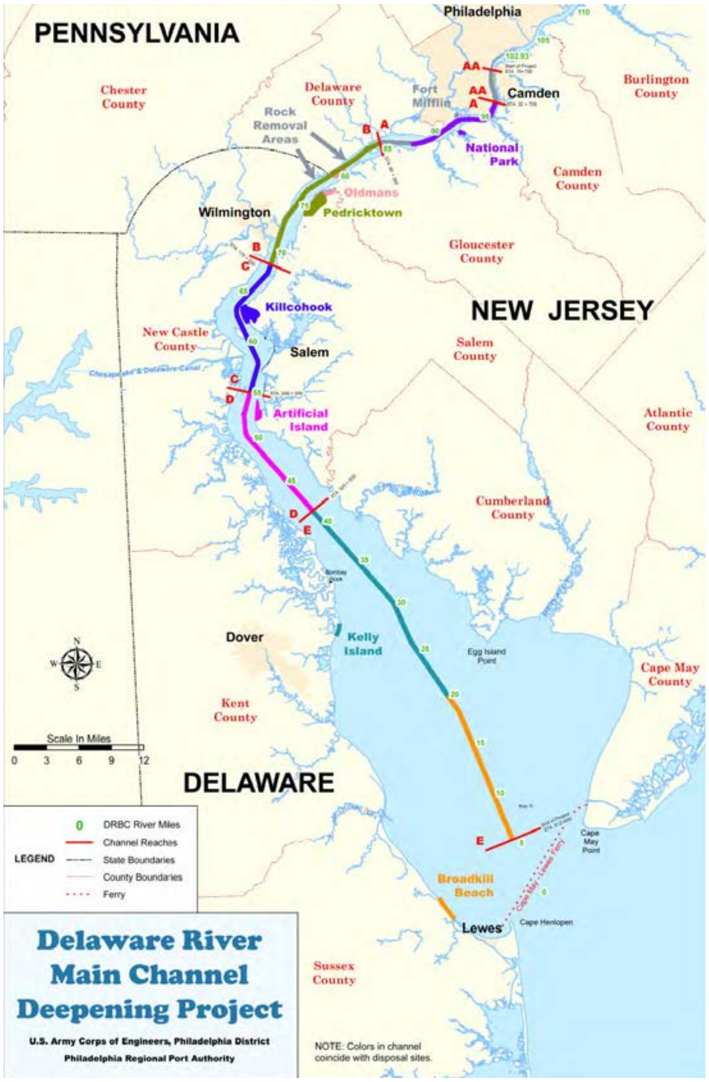


Figure 2: Illustration of the Deepening Project. Figure provided by USACE Philadelphia District.

On January 26, 2009, we received a letter from you requesting the reinitiation of consultation regarding the effects of the proposed deepening on listed species. You provided supplemental information on February 9, 2009. In February 2009, you also sent a letter 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 planned maintenance dredging. On March 12, 2009, you provided us with a revised project schedule and on April 3, 2009, you distributed a final Environmental Assessment (EA). Consultation was reinitiated on February 9, 2009.

We signed a Biological Opinion on July 17, 2009. In this Opinion, we 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. No interactions with any ESA listed species under our jurisdiction were observed during the first phase of the deepening in Reach C, which occurred from March – September 2010.

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 you. In March 2011, you 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, you published a draft supplemental EA. In an August 15, 2011, letter we provided you with technical assistance regarding upcoming dredging of Reach B. You 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 your reports on the tracking of tagged Atlantic and shortnose sturgeon during the dredging as well as a report on pre- and post-dredge substrate sampling.

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

Our 2012 Opinion analyzed effects of deepening of the Philadelphia to the Sea FNP, and included an Incidental Take Statement (for shortnose sturgeon, Atlantic sturgeon, and loggerhead and Kemp's ridley sea turtles) with Reasonable and Prudent Measures and Terms and Conditions. RPM #9, related to blasting in the Marcus Hook area, required you to submit to us a plan outlining the measures you would take to ensure that no shortnose or Atlantic sturgeon were present within 500 feet of the detonation site. The Term and Condition implementing this RPM stated that the plan may involve the use of an underwater imaging system (sonar fish finder, DIDSON, video etc.) to document the presence of fish in the area surrounding the blast site or could involve relocation trawling. In December 2013, you submitted a request to reinitiate consultation to consider effects of a relocation trawling pilot study. We considered the effects of this activity in a January 2014 Opinion. The 2014 Opinion also considered the effects of additional deepening of the Reedy Island Range (to 50 feet) to support the Oakwood Beach Storm Damage Reduction project.

The pilot study, conducted in February-April 2014, demonstrated that sturgeon could be effectively captured in the Marcus Hook area using commercial trawling gear and safely moved to a remote release location. More information on the pilot study is presented below (see Section 5.4.3). You also conducted a study in March-May 2015 to test the feasibility of using underwater sound to behaviorally exclude sturgeon from the blasting area. We considered effects of the sound deterrence pilot in a February 15, 2015 letter. This letter served as an amendment to the 2014 Opinion.

In the summer of 2015, you informed us of changes to the proposed blasting project. Due to the potential for ice to delay blasting operations in the Marcus Hook area, you determined that blasting would need to occur over two winters. The 2014 Opinion only evaluated the effects of blasting occurring over one winter (December 1 – March 15). You also proposed relocation trawling prior to and during the blasting at Marcus Hook and the use of a sound deterrent to attempt to minimize the number of sturgeon exposed to effects of blasting. In addition, new information available since the 2014 Opinion suggested that more shortnose and Atlantic sturgeon may be present in the Marcus Hook area during the winter than considered in previous Opinions. Therefore, reinitiation was necessary to (1) consider new information revealing effects of the action that may affect listed species in a manner or to an extent not previously considered; and (2) because the action would be modified in a manner causing effects to ESA listed species not previously considered. Consultation was reinitiated on August 20, 2015 and we issued a new Biological Opinion on November 20, 2015.

On December 14, 2015, you sent us a letter requesting reinitiation of the November 2015 Opinion; we concurred with that request in a January 11, 2016. Reinitiation was necessary because (a) the 2015 Opinion did not consider that sturgeon could be killed during relocation trawling and two young of year Atlantic sturgeon were killed on December 2, 2015 during pre-blast relocation trawling when a large stump entered the trawl net and crushed them; and, (b) pre-blast sturgeon relocation trawling revealed new information about the number of Atlantic sturgeon in the Marcus Hook area during the late fall and early winter. The 2015 Opinion expected a sturgeon capture ratio of 35 percent Atlantic sturgeon and 65 percent shortnose sturgeon, and exempted the non-lethal take of no more than 571 Atlantic sturgeon and 1061 shortnose sturgeon over the two (anticipated) blasting seasons. Pre-blast trawling from December 1 – December 19, 2015 resulted in the capture of 440 Atlantic sturgeon and 26 shortnose sturgeon (94% Atlantic sturgeon, 6% shortnose sturgeon). In our letter, we agreed to provide a new biological opinion within 135 days (i.e., April 27, 2016).

On May 5, 2016, we sent you another letter to formalize a 60-day extension of the consultation period, leading to a revised deadline of June 27, 2016. Our agencies first came to this agreement in an April 16, 2016 email. We agreed that the extension was necessary to provide additional time coordinate two necropsies on Atlantic sturgeon corpses that were incidentally collected in February and March of 2016 near the blasting site. The necropsies were needed to determine if the sturgeons' cause of death was related to blasting activities. We acknowledged that our agencies may need to discuss an additional extension in order to provide sufficient time for us to analyze and incorporate the necropsy results (we were provided the results on August 9, 2016). Also, we stated our intent to publish a proposed rule to designate critical habitat for Atlantic sturgeon in the spring of 2016. The extension of the consultation period allowed us to discuss the proposed rule with you following its publication and to make a determination as to whether a conference was necessary.

On June 3, 2016, we published two proposed rules (81 FR 35701; 81 FR 36078) to designate critical habitat for the five distinct population segments of federally listed Atlantic sturgeon. For the Delaware River, we proposed critical habitat for the New York Bight Distinct Population

Segment (DPS) from the Trenton-Morrisville Route 1 Toll Bridge downstream 137 river kilometers to where the main stem discharges at its mouth into the Delaware Bay (approximately RKM 76.5). Our agencies participated in a conference call on June 20, 2016 to discuss a path forward for addressing the effects of the Delaware deepening and maintenance dredging projects (Philadelphia to the Sea and Philadelphia to Trenton) on proposed critical habitat. At our suggestion, you decided to request conference.

On August 15, 2016, we received your letter requesting conference to assess the potential impacts of dredging, blasting, and placement activities associated with Delaware River channel deepening and maintenance on proposed critical habitat for Atlantic sturgeon. Therefore, your request asks us to consider the effects of the remaining deepening project, Philadelphia to the sea maintenance, Philadelphia to Trenton maintenance, as well as a new project, the Delaware River Dredged Material Utilization (DMU) study. We responded to your letter in an August 22, 2016 email in which we requested additional information to address (a) the frequency of maintenance dredging; (b) the predicted effects of blasting on hard bottom habitat; (c) how the projects will affect temperature, salinity, and dissolved oxygen; (d) how the projects will affect sturgeon use of habitat during and after the projects. On September 13, 2016, you submitted a revised request for conference, in which you concluded that while the projects are not likely to destroy or adversely modify proposed critical habitat for Atlantic sturgeon, you were still requesting conference to consider the projects' effects.

On February 22, 2017, we sent you a letter initiating formal consultation and also requested conference to consider the effects of the deepening project, the Philadelphia to the Sea and Philadelphia to Trenton maintenance dredging projects, and the DMU study. To streamline and consolidate these consultation processes, our agencies agreed to complete a new biological opinion to consider the effects of the Delaware River channel deepening project, Philadelphia to the Sea maintenance dredging, Philadelphia to Trenton maintenance dredging, and the DMU study. Therefore, the opinion replaced the 2015 Opinion (Delaware River channel deepening), the 2013 Opinion (Philadelphia to the sea), and the 1996 Opinion (Philadelphia to Trenton). To aid in the preparation of the Opinion, on April 25, 2017, you provided a supplemental analysis of the effects of the proposed actions on proposed Atlantic sturgeon critical habitat.

In a July 19, 2017 letter, the U.S. Coast Guard (USCG) requested informal consultation for the rebuild of the Marcus Hook light tower. In their letter, they explained that, "The purpose of the proposed action is to reposition the range structures as a result of the Delaware River channel dredging and deepening project completed by the U.S. Army Corps of Engineers (USACE)." Therefore, as explained below, this proposed work is an interrelated/interdependent action of the deepening and maintenance work and therefore, is appropriately considered in this Opinion. In an August 3, 2017 email, we advised you that we planned to include the light tower rebuild effects in the new Opinion. On September 28, 2017, we participated in a call with USCG to discuss the inclusion of their action in this Opinion and all parties agreed to move forward with that approach.

In a letter dated February 22, 2017, we informed you that we had the information necessary to reinitiate a formal consultation starting on February 2, 2017. Following this, we requested and you granted three extensions. On November 17, 2017, we issued a new Biological Opinion that replaced the previous opinions covering these activities:

- 2015 Opinion: Deepening of the Delaware River Federal Navigation Channel
- 2013 Opinion: Maintenance of the 40-foot Delaware River Federal Navigation Channel
- 1996 Opinion: Maintenance Dredging Operations within USACE's Philadelphia District

The 2017 Opinion includeed an analysis of the projects' effects on designated Atlantic sturgeon critical habitat, as we published the final rule in the Federal Register on August 17, 2017 (82 FR 39160; effective date: September 18, 2017).

In an email sent on February 2, 2018, we informed you that you exceeded the allowable non-lethal take of Atlantic sturgeon and shortnose sturgeon authorized in the Incidental Take Statement issued with the 2017 Biological Opinion.

In early February 2018, you informed us about the possibility that you may conduct blasting during a fourth season, (i.e. the winter of 2018/2019). You held a conference call on February 22, 2018 to explain why explosives are needed to remove additional rock pinnacles that could not be removed with dredging equipment. These rock pinnacles are located within the Marcus Hook Range of Reach B. During the conference call, we discussed the possibility of conducting the blasting within the timeframe (before March 15, 2018) covered by the 2017 Opinion. You agreed to calculate the amount of work and the number of dredges that would be needed to complete the blasting and clean-up before March 15, 2018. During our meeting, we also agreed, and you indicated that you understood, that if additional rock removal could not be completed within that time frame, then we needed to reinitiate consultation on the entire (deepening and maintenance) project and that you would develop a biological assessment (BA) with all information necessary to reinitiate consultation. We understand the work window for blasting is December 1 through March 15 with 14 days of relocation trawling before the commencement of blasting.

In an email sent on February 26, 2018, you concluded that time and budget constraints made it infeasible to do the proposed blasting before March 15, 2018. Further, you had originally proposed to deepen this reach of the navigation channel by using dredging equipment. The effects of using explosives to remove the rock pinnacles was not considered in the 2017 Opinion. Therefore, in a letter dated March 23, 2018, and received by us on March 26, 2018, you informed us that you intended to reinitiate formal consultation on the project. A biological assessment was not enclosed with the letter. In an email sent on March 27, 2018, we agreed that reinitiation is necessary based on 1) the exceedance of incidental take and 2) the modifications to the proposed project in a manner that causes effects to the listed species and critical habitat that were not considered in the 2017 Opinion. However, we noted that consultation is not initiated until we have received a biological assessment containing all the information necessary for an adequate review of the effects that the action may have upon listed species and critical habitat.

On June 4, 2018, we received an email from you with an attached letter that requested reinitiation of formal consultation on the remaining deepening activities. The email also included a draft biological assessment for the updated project. The biological assessment included a description of the additional blasting, the related proposed relocation trawling, the use of a sound deterrent system, and the effects these activities may have on listed sturgeon. We acknowledged the receipt of your letter and the BA in an email sent on June 4, 2018. In the email, we informed you that we would review the BA for completeness and that formal consultation is not initiated until we have all the information necessary to analyze the effects of the proposed action on listed species. On June 24, 2018, we sent you an email informing you that we had reviewed the biological assessment and concluded that we had not received all the information necessary to begin formal consultation. In the email, we requested additional information and provided comments on the draft biological assessment. We also informed you that the reinitiation would include the whole project as analyzed in our 2017 Opinion and would not be limited to the proposed additional blasting and relocation trawling proposed for the 2018/2019 season.

We provided additional technical assistance by email, phone, and meetings through September 2018. During our communications, it was made clear that you proposed additional modifications to the project description beyond what was described in the 2017 Opinion. These include, but are not limited to: the total years of dredging activities for the deepening, changes in the volume of dredged material for the beneficial use, the use of the Buoy 10 open water disposal site.

On August 20, 2018, we sent you an email requesting additional information on the use of explosives and relocation trawling as well as on other project activities. In an email sent on September 18, 2018, you provided us with the information we requested in our email sent on August 20, 2018. Consequently, we sent you a letter dated September 25, 2018, informing you that based on this additional information, we concluded that we had received all information necessary to analyze effects to listed species and critical habitat under our jurisdiction and that formal consultation could be initiated. The formal consultation was reinitiated on September 18, 2018, when we received the additional information that we had requested.

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 construction, dredging, and disposal activities, as well as the area transited by project vessels. You have proposed dredging and disposal activities related to the maintenance of the Philadelphia to the Sea 45-foot FNP and Philadelphia to Trenton FNP for 50 years (through 2068). The navigation channel from the Sea to Trenton stretches from approximately RKM 5 to RKM 214.5, and encompasses an area you have estimated to be 11,568 acres. The action area also includes the area where relocation trawling will occur (in Marcus Hook) and the area where sturgeon will be relocated to (Mifflin Range, Torresdale Range and Keystone Channel, all located within 48 km upriver of Marcus Hook). Additionally, the action area includes the beneficial use disposal areas at Oakwood Beach and the DMU sites (seven Delaware Bay front communities in Delaware, and three in New Jersey), as well as the area impacted by the installation of the Marcus Hook range lights (an interrelated activity proposed by the U.S. Coast Guard) described below. The action area will also encompass the effects of in water construction. Blasting effects will be limited to an area with a radius of 500 feet around the detonation sites). We expect the effects of pile driving to be limited to a 607-foot radius around the piles during installation. The size of the sediment plumes from construction will vary depending on the type of dredge used. The largest plume would likely occur from a mechanical dredge, which could have a sediment plume with a radius of 1,464m. Where the Delaware Bay narrows into the main stem of the Delaware River, the river is approximately 5,000m, but quickly narrows to approximately 2,000m near New Castle, DE, and narrows further before Philadelphia (~1,000m), before reaching its narrowest points closer to Trenton, NJ (~250m). Therefore, the action area overlaps with the vast majority of the bank-to-bank Delaware River, as well as most of Delaware Bay, as beach nourishment activities occur up and down the coast of the Bay in Delaware and New Jersey. We have calculated a rough estimate of the action area to be 472,158 acres. Table 1, below shows all of the proposed parts of the action, the time of year when the work is anticipated to occur, and the equipment used.

Table 1: Proposed Project Activities, Methods, and Dates

Federal Project	Activity	Channel Reach/ Location	River miles & (RKM)	Duration (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applicable)	Original Scheduled Dates	Remaining Volume/Acers	New Scheduled Dates
Main Channel Deepening and Philadelphia to the Sea (45' maintenance)	Maintenance dredging	E	5-41 (8-66)	2-3	Annual	45'	400,000	Hopper	Buoy 10	All Year	NA	No change
	Deepening	E	19-41 (30.6-66)	12	1 Season	45'	1,300,000	Hopper and Mechanical	Artificial Island CDF, Buoy 10	December 2017 – March 2018	0	Completed August 31, 2018
	Maintenance dredging	D	41.1-55 (66.1-88.5)	2-3	3-Year Cycle	45'	1,000,000 (includes 33,000 for Oakwood Beach every 8 years)	Hopper & Cutter-Suction	Artificial Island CDF	All Year	No change	No change
	Maintenance dredging	C	55.1-67 (88.7-107.8)	2-3	Annual	45'	2,000,000	Cutter-Suction & Hopper	Killcohook and Pedricktown CDFs	All Year	No change	No change
	Deepening	B	67.1-85 (108-136.8)	7	1 Season	45'	400,000	Blasting	N/A	December 1, 2017 – March 15, 2018	0	Completed
	Original Blasting Deepening clean-up	B	67.1-85 (108-136.8)	17	1-2 Seasons	45'	400,000	Mechanical	Fort Mifflin CDF and Cape May Artificial Reef	July 1, 2017 – March 15, 2018 (possibly July 1, 2018 – March 15, 2019)	0	Completed
	Deepening	B	78-84 (125.5-135.2)	1	1 Season	45'	25,000	Blasting of rock pinnacles	N/A	NA	25,000 over 20 acres	December 1, 2018, to March 15, 2019 or 1

Federal Project	Activity	Channel Reach/ Location	River miles & (RKM)	Duration (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applicable)	Original Scheduled Dates	Remaining Volume/Acres	New Scheduled Dates
												December 2019, to March 15, 2020
	Additional proposed blasting clean up	B			1 Season	45’		Mechanical	Fort Mifflin CDF and Delaware Artificial Reef	NA	25,000 CY over 20 acres	December 1, 2018, to March 15, 2019 or July 1, 2019, to March 15, 2020 or July 1, 2020, to March 15, 2021
	Deepening	B	67.1-85 (108-136.8)	10	1 Season	45’	4,000,000	Cutter-Suction & Mechanical	Oldmans and Pedricktown CDFs and Delaware Artificial Reef	August 1, 2017 – March 15, 2018; August 1, 2018 – October 30, 2018	350,000 CY over 100 acres	August 1, 2018 to March 15, 2019 or July 1, 2019, to March 15, 2020.
	Maintenance dredging	B	67.1-85 (108-136.8)	2-3	Annual	45’	2,700,000	Hopper & Cutter-Suction & Mechanical	Oldmans and Pedricktown CDFs	July 1 – March 15	No change	No change
	Maintenance dredging	A	85.1-97 (137-156.1)	2-3	5-Year Cycle	45’	200,000	Mechanical & Hopper & Cuttersuction	National Park & Fort Mifflin CDFs	July 1 - March 15	No change	No change
	Maintenance dredging	AA	97.1-102 (156.3-164.2)	2-3	5-Year Cycle	45’	450,000	Mechanical & Hopper	National Park & Fort Mifflin CDFs	July 1 – March 15	No change	No change
Philadelphia to Trenton (maintenance)	Maintenance dredging	A-B (Allegheny Ave., Philly to Burlington Island)	109.93 - 118.87 (176.9-191.3)	1-3	Annual	40’ deep; 400’ wide	100,000-200,000	Hopper, Cutter-head, or Mechanical	Palmyra Cove, Burling-ton Island, Money	June 1 – March 15	No change	No change

Federal Project	Activity	Channel Reach/ Location	River miles & (RKM)	Duration (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applicable)	Original Scheduled Dates	Remaining Volume/Acers	New Scheduled Dates
									Island, Biles Island, Fort Mifflin			
	Maintenance dredging	A-B (Burlington Island to Newbold Island, Bucks County)	118.87 - 126.88 (191.3-204.2)	1-3	2-3 year cycle	40’ deep; 400’ wide	700,000	Cutterhead or Mechanical	Money Island, Biles Island	July 1 – March 15 (Mechanical); July 1 – December 31 (Cutter-head)	No change	No change
	Maintenance dredging	B-C (Newbold Island to Trenton Marine Terminal)	128.66 - 132.06 (207.1-212.5)	10-20 days	3-5 years	25’ deep; 300’ wide	150,000	Cutterhead or Mechanical	Money Island, Biles Island	July 1 – March 15 (Mechanical); July 1 – December 31 (Cutter-head)	No change	No change
	Maintenance dredging	C-D	132.07 - 133.29 (212.5-214.5)	1-3	Not routinely maintained – (USACE hasn’t dredged here in 30+ yrs)	12’ deep; 20’ wide	<100,000	Cutterhead or Mechanical	Money Island, Biles Island	Oct. 1 – March 15	No change	No change
	Maintenance dredging	Fairless Turning Basin	126.88 (204.2)	1	2 year cycle	40’	200,000	Cutterhead	Money Island	July 1 – March 15	No change	No change
DMU	Delaware Beach Nourishment – Initial construction (2020 – Lewes Beach, Prime Hook Beach and Slaughter Beach)	Lower Reach E (Miah Maull and Brandywine Ranges)	5-26 (8-41.8)	6	2 year cycle	Sand from 45’ Maintenance	730,000	Hopper Dredge	3 DE bayfront communities	2020 (estimated) Work may occur all year	730,000 (updated volume)	No change
	Delaware Beach	Lower Reach E	5-26 (8-	10	2 year cycle	Sand from 45’	900,000		7 DE bayfront	2026 (estimated)	900,000 (updated	2026

Federal Project	Activity	Channel Reach/ Location	River miles & (RKM)	Durat-ion (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applic-able)	Original Scheduled Dates	Remaining Volume/Acers	New Scheduled Dates
	Nourishment – Initial Construction (2026 – Pickering Beach, Kitts Hummock, Bowers Beach and South Bowers Beach)	(Miah Maull and Brandywine Ranges)	41.8)			Maintenance			commun-ities	Work may occur all year	volume)	
	Delaware Beach Nourishment – periodic -- Lewes Beach, Prime Hook Beach and Slaughter Beach (2032 to 2068)	Lower Reach E (Miah Maull and Brandywine Ranges)	5-26 (8-41.8)	7	6 year cycle	Sand from 45' Maintenance	400,000	Hopper Dredge	7 DE bayfront commun-ities	N/A	2,800,000 (total until 2068)	2020-2068
	New Jersey Beach Nourishment – initial construction (2022 – Gandys Beach and Fortescue)	Lower Reach E (Miah Maull and Brandywine Ranges)	5-26 (8-41.8)	6	2 year cycle	Sand from 45' Maintenance	550,000	Hopper Dredge	2 NJ bayfront commun-ities	2022 (estimated) Work may occur all year	550,000 (updated volume)	No change
	New Jersey Beach Nourishment – initial construction (2028 – Villas South)	Lower Reach E (Miah Maull and Brandywine Ranges)	5-26 (8-41.8)	6	2 year cycle	Sand from 45' Maintenance	600,000	Hopper Dredge	3 NJ bayfront commun-ities	2028 (estimated) Work may occur all year	600,000 (updated volume)	2028
	Beach Nourishment – periodic - Gandys	New Jersey Beaches: Lower Reach E	5-26 (8-41.8)	6	6 year cycle	Sand from 45' Maintenance	180,000	Hopper Dredge	3 NJ bayfront commun-ities		1,260,000 (total until 2070)	2034-2070

Federal Project	Activity	Channel Reach/ Location	River miles & (RKM)	Durat-ion (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applic-able)	Original Scheduled Dates	Remaining Volume/Acers	New Scheduled Dates
	Beach and Fortescue (2034 – 2070)	(Miah Maull and Brandywine Ranges)										
Marcus Hook Range Lights	Pile driving and excavation	Marcus Hook Reach	74.5-75.5 (119.9-121.5)	120-210 days	One time event	NA	~200 CY	Impact/Vibratory Hammer; Auger	NA	August 1 – March 15		

For maintenance dredging of the Federal navigation channel from Philadelphia to the Sea and Philadelphia to Trenton, you have indicated that the vast majority of dredging, in terms of area, volume and frequency, occurs in the following areas (the times of year and equipment for dredging will conform to the information provided for the corresponding reaches in Table 1):

Table 2: Location, Area, and Dredge Frequency of Major Shoaling Sites for Maintenance Dredging of the Federal Navigation Channel (data provided via email on November 3, 2017)

Shoal Location	**Corresponding Reach**	**Shoal Area (acres)**	**Shoal Material**	**Dredge Frequency**	**RKM (Downstream)**	**RKM (Upstream)**
New Castle Range*	C	202	silt/fine grained sand	Annual	97.2	100.9
Deepwater Range*	C (plus 0.5 km of Reach B)	386	silt	Annual	101.9	108.3
Cherry Island Range	B	239	silt	1-4 years	112.8	116.8
Marcus Hook Range	B	184	silt	Annual	127.1	130.2
Bridesburg/Frankford Ranges Intersection.	A-B (between Allegheny Ave and Burlington Island)	13.7	fine/medium grained sand	1-2 years	170.8	171.7
Torresdale Range	A-B (between Allegheny Ave and Burlington Island)	13.7	fine/medium grained sand	1-2 years	175.6	176.5
Enterprise Range	A-B (between Allegheny Ave and Burlington Island)	8.6	fine/medium grained sand	1-2 years	183.5	184.2
Beverley/Edgewater Ranges Intersection	A-B (between Allegheny Ave and Burlington Island)	18.3	fine/medium grained sand	1-2 years	185.6	186.8
Edgewater Range	A-B (between Allegheny Ave and Burlington Island)	9.1	fine/medium grained sand	1-2 years	188.1	188.7
Keystone Range	A-B (between Burlington Island and Newbold Island)	5.8	75% silts and 25% fine sands	3-4 years	192.8	193.5
Landreth Range	A-B (between Burlington Island and Newbold Island)	5.2	75% silts and 25% fine sands	3-4 years	193.7	194.4
Foundry/Church Ranges	A-B (between Burlington Island and Newbold Island)	5.7	75% silts and 25% fine sands	3-4 years	196.7	197.4
Florence Range	A-B (between Burlington Island and Newbold Island)	8.6	75% silts and 25% fine sands	3-4 years	195.8	196.8

Shoal Location	**Corresponding Reach**	**Shoal Area (acres)**	**Shoal Material**	**Dredge Frequency**	**RKM (Downstream)**	**RKM (Upstream)**
Florence/Roebling	A-B (between Burlington Island and Newbold Island)	13.8	75% silts and 25% fine sands	3-4 years	199.1	200.9
Kinkora Range (A)	A-B (between Burlington Island and Newbold Island)	20.5	75% silts and 25% fine sands	3-4 years	199.4	201.1
Kinkora Range (B)	A-B (between Burlington Island and Newbold Island)	15.6	75% silts and 25% fine sands	3-4 years	200.2	203.3
Penn/Newbold Ranges	A-B (between Burlington Island and Newbold Island)	9.6	75% silts and 25% fine sands	3-4 years	202.2	203.5
Fairless Turning Basin	A-B (between Burlington Island and Newbold Island)	16.5	75% silts and 25% fine sands	3-4 years	202.9	203.9
Totals:	N/A	**1175.7**	N/A	N/A	N/A	N/A

*You indicated that you expect to dredge these ranges annually for the next five years to initially maintain the 45-ft channel; however, after 5+yrs these ranges they will be maintained on a 4-year frequency as the newly deepened channel reaches equilibrium over time.

3.1.1 Physical Characteristics of the Action Area

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

Artificial Island is located approximately 3.2 km upstream of the hypothetical line demarking the head of Delaware Bay. The tidal river in this area narrows upstream of Artificial Island and makes a bend of nearly 60 degrees. Both the narrowing and bend are accentuated by the presence of Artificial Island. More than half of the typical river width in this area is relatively shallow, less than 18 feet (5.5 meters), while the deeper part, including the dredged channel has depths of up to 40-45 feet (12.2-13.7 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. The salt front location varies depending on the season and freshwater input, with the median monthly salt front (0.25 ppt) ranging from RKM 107.8 to RKM 122.3 (DRBC 2017). The historic salt front location is reported as approximately RKM 92. Given its dynamic nature, for the purposes of this Opinion, we refer to the salt front as RKM 107.8.

Tidal flow as measured near the Delaware Memorial Bridge (RKM 108), 32 kilometers above

Artificial Island, was measured at 399,710 cfs (11,320 cubic meters per second) (USGS, 1966). Tidal flow of this magnitude is 17 times as great as the total average freshwater flow rate into the estuary. Proceeding toward the mouth of the estuary, tidal flow increasingly dominates freshwater downstream flow; proceeding upstream from the Delaware Memorial Bridge, the ratio of tidal flow to net downstream flow becomes smaller as tidal influence decreases.

You have determined that the navigation channel where deepening and maintenance work will occur constitutes 2.4 percent of the Delaware River and Bay watersheds (mainstem of the river plus the Bay). Within the four areas of the channel, the percentage of area taken up by the channel never exceeds 17 percent (See Figure 3). Area 1 is approximately Reaches E, D, and C; Area 2 is approximately Reaches B, A, AA; Area 3 is approximately Reach A-B; Area 4 is approximately Reaches B-C and C-D.

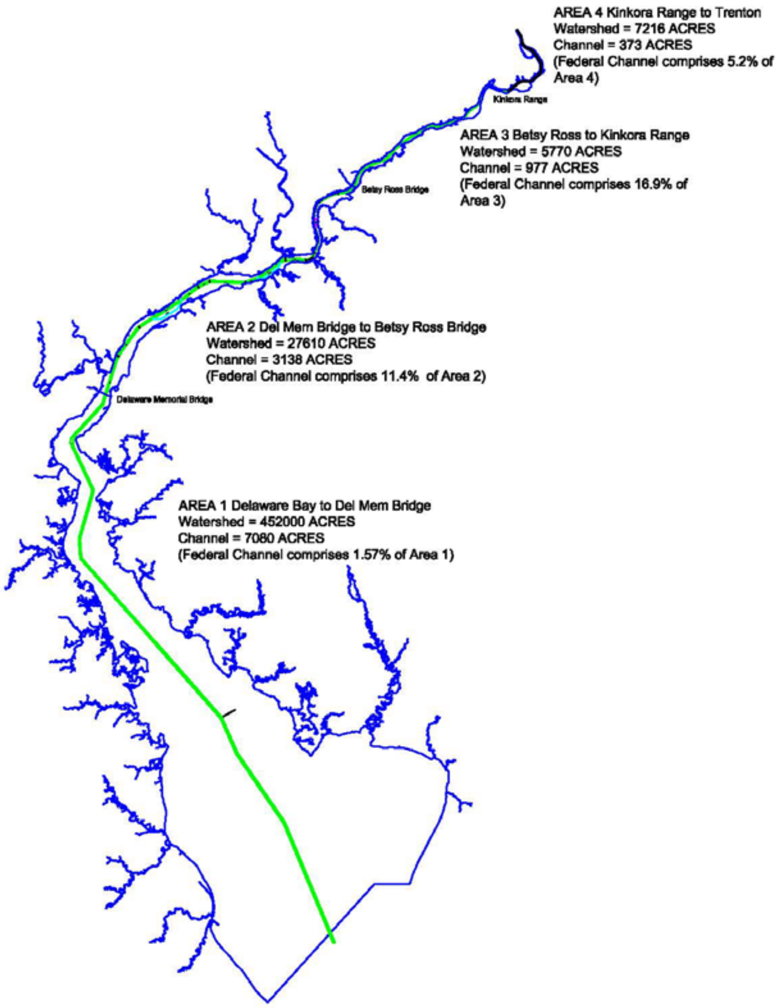


Figure 3: Navigation Channel Area Compared to the Delaware River and Bay (USACE provided to NMFS on April 25, 2017)

3.2 Philadelphia to the Sea Deepening (45-foot channel)

The deepening project as authorized by Congress (shown in Figure 2) 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 Figure 2. The lowermost end of Reach E is located approximately 8 RKM from the theoretical line between Cape Henlopen and Cape May Point. Approximately 16 million cubic yards of material will be removed from the channel to deepen it from 40 to 45 feet.

The existing channel is maintained at a depth of 40 feet deep at mean low water (MLW). Only portions of the channel that are currently between 40 feet and 45 feet MLW will be dredged for the deepening project. The surface area of the Delaware estuary from the Ben Franklin Bridge to the capes (excluding tidal tributaries) is approximately 700 square miles. The Philadelphia to the Sea Federal navigation channel has a surface area of 15.3 square miles, or approximately 2.2 percent of the total estuary surface area, of which 8.5 square miles will be dredged to 45 feet. See Table 1 for a description of the amount of material that was removed and the amount of material that remains to be removed from each channel range.

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

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

All channel bends modifications have been completed to date and the described modifications will be maintained in the future:

1. MIAH MAULL-CROSS LEDGE: 200 foot width increase at the apex of the west side of the bend (part of Upper Reach E contract);
2. 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);

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. 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. 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. 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. BELLEVUE-MARCUS HOOK: The east apex of the bend requires a 150 foot widening over existing conditions, along a total length of approximately 4,000 feet (BW7 - channel station 141 + 459)(part of Reach B contract);
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)(part of Reach B contract);
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)(part of Reach B contract);
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)(part of Reach B contract).
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).

3.2.1 Material Remaining to be Removed
As of the fall of 2018, initial deepening (not including maintenance dredging), is nearly complete. The initial deepening work remaining includes (also see Table 1):

- Reach B: removing approximately 25,000 cy of rock (~20 acres) in the vicinity of Marcus Hook, Pennsylvania (RKM 125.5-135.2) and placed in the Fort Mifflin confined disposal facility in Philadelphia or the Cape May Artificial Reef. Blasting will be used in this area, followed by removal of rocky material with a mechanical dredge. Blasting will take approximately 30 days between December 1, 2018 and March 15, 2019 or between December 1, 2019 and March 15, 2020, depending on funding. Mechanical dredge rock removal will occur from July 1, 2019 – March 15, 2020 (or alternatively July 1, 2020 – March 15, 2021).
- Reach B: removing approximately 350,000 cy (~100 acres) of dredged material via cutterhead and mechanical dredge from RKM 125.5-135.2. Cutterhead dredging will occur during the period from August 1, 2018 to October 30, 2019 and mechanical dredging will occur during the period from July 1, 2018 to March 15, 2019. If dredging cannot be completed by March 15, 2019, the work will continue and will be completed by March 15, 2020, with inclusion of the appropriate dredging restrictions (cutter-suction: no dredging between March15 and July 31; mechanical: no dredging between March 15 and June 30). This change is dependent on funding. Material will be placed in an upland CDF (Oldmans, Pedricktown or White’s Basin).

3.2.2 Material Disposal
As stated above, all reaches have now been completed with the exception of Reach B where approximately 375,000 cubic yards remains to be removed by blasting and dredging. The rock removed following the blasting in Reach B will be transported to the Ft. Mifflin CDF (RKM 146.9) or to approved DNREC artificial reef sites in the Delaware Bay (Corps Permit CENAP-2017-703-85). The material dredged from upper Reach B using cutterhead and mechanical dredges will be pumped directly to Oldman’s (RKM 121) or Predricktown CDF.

3.2.3 Avoidance and Minimization Measures during Blasting
You propose several measures to avoid and minimize effects from the use of explosives. These measures include 1) removing sturgeon from the blast impact zone by capturing within the blast zone with a trawl (relocation trawling) and relocating the sturgeon upstream of the work area, 2) tagging a sample of sturgeon with acoustic transmitters to follow movements in and out of the blast zone so that blasting can be delayed until sturgeon move out of the area, and 3) using acoustic deterrence to have any sturgeon move out of the blast zone just prior to blasting and until any detected tagged sturgeon have moved out of the area. You also propose to conduct monitoring of the waters immediately following the blast so that any injured or dead sturgeon can be observed and collected. Table 3 provides a summary of proposed sturgeon monitoring and protection.

Table 3. Summary and Schedule of Sturgeon Monitoring and Protection

Task	**Schedule**
Relocation trawling	Two weeks intensive trawling immediately prior to start of blasting. Additional trawling nominally every other day during blasting period. Trawling schedule and intensity to be modified, as necessary, based on tracking of acoustically tagged sturgeon (see details below).
Blast pressure monitoring	During first three detonations.
Operation of Acoustic Deterrent System	Continuous operation at least five hours before each detonation.
Far-field monitoring of acoustically-tagged sturgeon	Starting two weeks prior to start of blasting and continuously during the blasting period.
Near-field monitoring for acoustically-tagged sturgeon at the blast site	Immediately prior to each detonation.
Use scare charges for each blast	Two scare charges, 45 and 30 seconds prior to each blast
Surface monitoring for injured or dead sturgeon	Immediately following each detonation.

3.2.3.1 Trawling and Relocation

Blasting is scheduled to occur only between December 1 through March 15. Accordingly, sturgeon relocation will be performed in approximately the same period.

For two weeks prior to the commencement of the blasting season (approximately mid to late November in 2018 or 2019), you will trawl intensively in the Marcus Hook blasting area in an attempt to remove as many Atlantic and shortnose sturgeon as possible. The goal of the relocation trawling is to minimize the number of sturgeon present within a 500-foot radius of any detonation. It will not be possible to trawl within the immediate vicinity of a blasting site once the charges are being set. Once blasting begins, trawling will be performed every other day (weather permitting) to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver.

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

Headrope	16.2 m (53 ft.)
Footrope	22.8 m (75 ft.)
Net body mesh	14 cm (5.5 inch)
Codend mesh	7.6 cm (3 inch)
Innerliner mesh	3.2 cm (1.25 inch)

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

Sturgeon will be carefully removed from the net and quickly placed in a floating net pen or on-board tank containing river water at ambient temperature and dissolved oxygen levels. Exposure of the sturgeon to cold air will be minimized to the extent possible. Processing of sturgeon will follow the protocols of Kahn and Mohead (2010). Sturgeon will be identified to species, measured for fork length (FL) and total length (TL) to the nearest millimeter, and weighed to the nearest gram.

In the previous seasons, an approximately 1 cm^2 piece of pelvic fin was clipped and retained in ethanol for genetic analysis. However, no tissue samples will be collected during the fourth season. Sturgeon of sufficient size will be tagged with a numbered T-bar tag and/or a passive integrated transponder (PIT) tag, and an acoustic transmitter.

3.2.3.2 Acoustically-tagged sturgeon

A maximum of 100 sturgeon (from December 2017 – March 2018) of those captured by trawl and relocated to upriver release locations will be internally tagged with a VEMCO acoustic transmitter (see Section 7.5.3 for details). We expect the 100 sturgeon to be a mix of shortnose and Atlantic sturgeon that will be representative of the ratio of the total sturgeon captured and relocated. Tracking acoustically tagged sturgeon following relocation will provide information on the extent and rates at which sturgeon are moving back toward the blasting area. The total weight of tags will not exceed 2 percent of the sturgeon's body weight. Sturgeon for acoustic tag implantation will be anesthetized using tricane methanesulfonate (MS-222) at a dose of 50 mg/L and then held upside down in a cradle where the gills will be perfused with aerated flowing water. The transmitter will be inserted into the body cavity through a small longitudinal incision in the abdomen. The incision will be closed with interrupted sutures of 3-0 polydioxanone (PDS) and treated with povidone iodine (10% solution) and petrolatum to prevent infection.

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

During transport, sturgeon will be held in an on-board tank(s) supplied with ambient river water at a rate sufficient to allow for total replacement of water volume every 15 minutes. Dissolved oxygen concentration in the holding tank will be periodically measured using a hand-held meter.

Backup oxygenation with compressed oxygen will be provided, if necessary, to ensure sturgeon do not become stressed and dissolved oxygen concentrations remain at or above 4.5 mg/L, consistent with the recommendations in Kahn and Mohead 2010. If an unusually large catch occurs, sturgeon may be held in a floating net pen for a period not to exceed four hours prior to transport.

3.2.3.3 Acoustic Deterrence

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

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

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

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

3.2.3.4 Sturgeon Monitoring during Blasting

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

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

3.3 Philadelphia to the Sea Maintenance Dredging (45-foot channel)

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.

As explained above, the proposed action under consideration in this consultation includes annual maintenance dredging through 2068 (50 years) as shown in Table 1. Maintenance dredging can begin as soon as the year after deepening begins, depending on the rate of sedimentation in a particular reach, which is influenced by river morphology, sediment type and natural conditions such as tides, currents and storms. Maintenance dredging has begun in Reaches C, D and portions of A and B. The deepening dredging of upper Reach E was concluded on August 31, 2018, and maintenance dredging of upper Reach E may commence on July 1, 2019.

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 (Table 1).

The timing and duration of maintenance dredging in the Bay (Reaches D and E) varies but typically occurs in the summer and fall. Both hopper and cutterhead dredges will be used for maintenance of Reach D. Dredged material will be disposed of at the existing upland disposal site Artificial Island CDF. The USACE will use the McFarland or similar hopper dredge for open water disposal (at Buoy 10) during maintenance of Reach E in the Delaware Bay. This dredge can work a maximum of 70 days a year in the bay. The dredge is able to make two to three trips a day to Buoy 10, depending on the location of the shoal. Thus, 140 to 210 loads of material could be placed at Buoy 10 in a year. This would vary annually with the amount of shoaling, but it is estimated that 400,000 cubic yards of material could be moved with the McFarland over a 70-day period. This estimate is an increase of 240,000 cubic yards from what was considered in the 2017 Opinion for this project (Table 1).

3.3.1 Material Disposal

Dredged material from maintenance of the Philadelphia to the Sea channel will either be disposed of at existing disposal sites or be utilized for beneficial use. Disposal sites includes several upland CDFs and one open water disposal site (Table 1).

The current dredged material disposal plan for the riverine portion of the project (Reach AA to C) will utilize the existing upland Federal disposal sites:

- Dredged material from the maintenance of Reach A (approximately 200,000 cy every 5 years) and Reach AA (approximately 450,000 cy every 5 years) will be disposed of at National Park & Fort Mifflin CDF.
- Dredged material (approximately 2,700,000 cy/yr) from the maintenance dredging of Reach B will also be disposed of at the Oldman's and Predicktown CDF.
- Dredged material (approximately 2,000,000 cy/yr) from maintenance dredging of Reach C will be disposed of at the Killcohook and Pedricktown CDFs.

In the Delaware Bay (Reaches D and E), material will be deposited at upland and open water disposal sites or used for beneficial use projects:

- Dredged material from maintenance of Reach D (approximately 1,000,000 every 3 years) will be disposed of at the Artificial Island CDF and at the Oakwood Beach beneficial use site (see Section 3.3.4).
- Dredged material from maintenance of Reach E (approximately 400,000 cy/yr) will be disposed of at the open water disposal site Buoy 10 (see Section 3.3.3) and used for the Dredge Material Utilization (DMU) study (see Section 3.3.5).

A description of CDFs, the Buoy 10 site, and beneficial use sites follows below.

3.3.2 Upland CDF Sites

Dredging with clamshell (mechanical) or hopper dredge includes transporting the material to the approved CDF where the dredged material is mechanically or hydraulically offloaded to the upland CDF. When dredging with a cutterhead, the dredged material is sucked in as a solid/water slurry. Usually, the slurry is pumped directly to a nearby disposal site using pumps and a floating pipeline though it may be loaded onto a barge for transport to a remote CDF.

A CDF is a large settling basin designed to accept and dewater dredged material. When in operation, a mixture of dredged material and water is pumped into one end of the CDF. As the mixture flows through the CDF, the solids settle to the bottom and the water flows to the discharge location where it flows back into the river. Water pumped with the dredged material must be contained in the CDF until sufficient solids settle out. Heavier, coarser-grained sands and gravels drop out of the water column close to where material enters the CDF. As the water moves through the CDF it slows, allowing finer-grained sediment particles to settle out. Finally, water reaches the weir and is discharged from the site. The purpose of the weir structure is to regulate the release of ponded water from the CDF. As the height of the weir is increased, the depth of the pond increases and only the cleaner surface waters of the pond are released. The discharged water is required by state regulations to contain a suspended sediment concentration that is less than the receiving water body.

3.3.3 Open Water Disposal (Buoy 10)

A large hopper dredge (McFarland or similar dredge) will be used for maintenance of Reach E and the dredged material will be placed at the open water Buoy 10 disposal site (Figure 4). The site is 2000 feet by 2000 feet (approximately 92 acres) in size and is bounded by the following coordinates (decimal degrees):

Corner	Northing	Easting
1	38.94737	-75.08733
2	38.94485	-75.08595
3	38.94593	-75.08273
4	38.94845	-75.08406

The site is only approved for coarse-grained material greater than 90 percent sand. The bottom substrate at this site is sand and the majority of the site is greater than 40 feet deep with one area (closed for material disposal) with a depth of 25 feet MLLW or less. There are no seasonal restrictions in place and Buoy 10 is available for use year round.

The primary component of a hopper dredge is the hopper, which is used to contain and transport dredged material. During the dredging process, sediments sucked up through the intakes are mixed with water to create a slurry, which is typically about 25 percent solids and 75 percent water, and the slurry is then pumped into the hopper. As the hopper fills with the slurry, the sediments begin to settle to the bottom of the hopper, creating a bottom layer of heavier larger grained sediments with a top layer of lighter supernatant. Coarse-grained sediments (sediments with high percentages of sand/gravel) and consolidated clay sediments settle to the bottom faster than fine-grained sediments (unconsolidated silts and clays). Buoy 10 is only approved for the placement of coarse-grained sand. Once the hopper is filled, the dredge will travel to the Buoy 10 site. When the hopper dredge is located within the site, the bottom doors of the hopper open to release the load and the sandy sediments will sink to settle at the bottom within the boundaries of the site.

3.3.4 Oakwood Beach (Delaware)

Periodic (approximately every eight years) removal of 33,000 cubic yards of sand from a 3 km section of the navigation channel extending from the northern point of Reedy Island (Reach D) will be dredged for the nourishment of Oakwood Beach. This work will maintain the depths in this area between 45 and 50 feet.

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

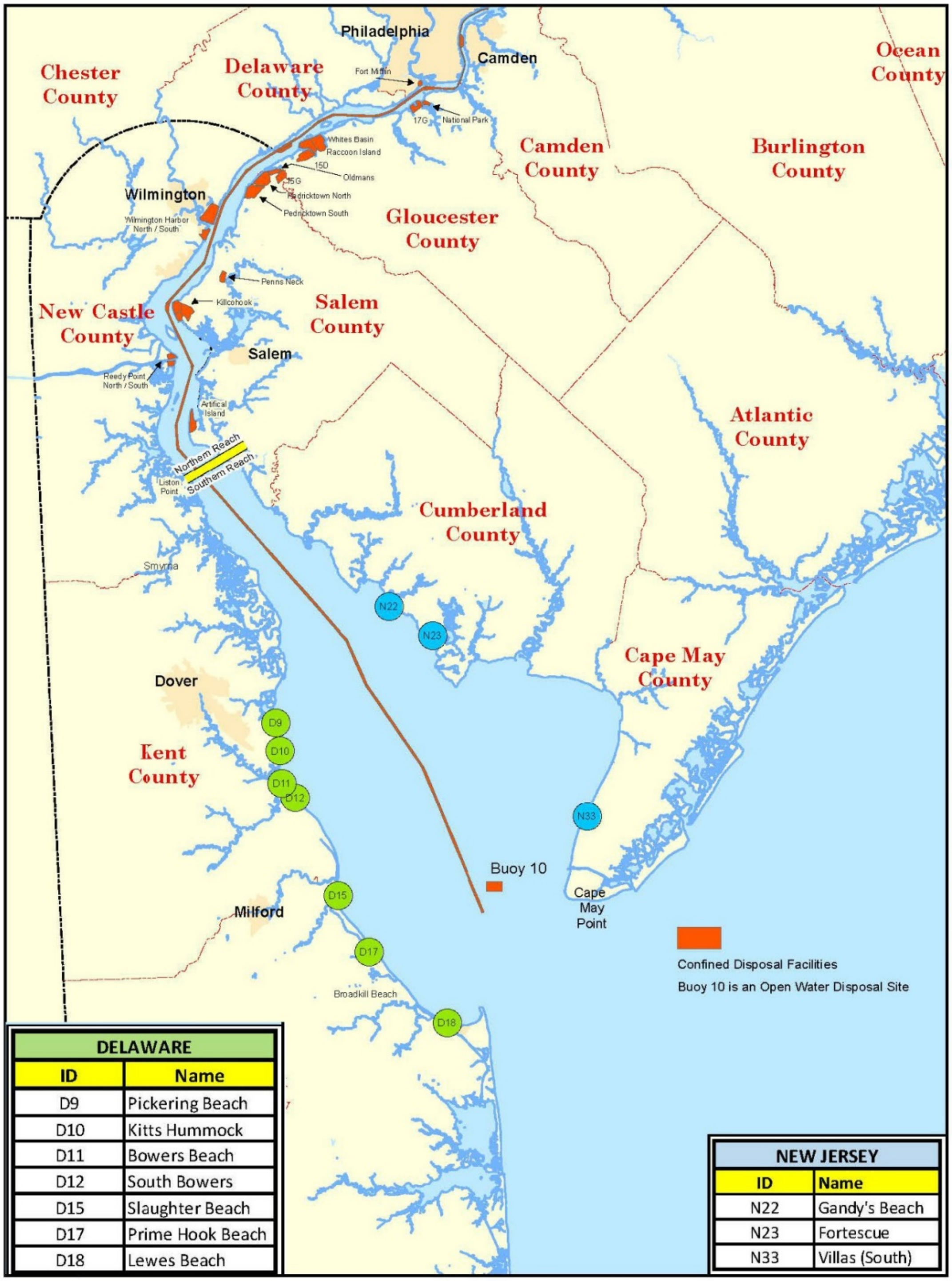
- A 50-foot berm at an elevation of +6.0 feet NAVD for a total length of 9,500 feet. On top of the berm lies a dune with a top elevation of +16 feet NGVD and a top width of 25 feet (completed)
- Extension of five stormwater outfall pipes to be supported by timber cribbing mounted on 20-foot long 12-inch diameter piles spaced 18-feet apart (completed)
- Placement of 354,000 cubic yards of sand on Oakwood Beach for initial nourishment (completed)
- Periodic nourishment of 33,000 cubic yards of sand fill would be placed every 8 years starting in 2023.

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

3.3.5 Dredge Material Utilization (DMU) Study

In a May 25, 2017 email, you stated that the DMU study now consists of seven Delaware beach restoration sites (Pickering Beach, Kitts Hummock Beach, Bowers Beach, South Bowers Beach, Slaughter Beach, Prime Hook Beach and Lewes Beach) and three New Jersey beach restoration sites (Gandy's Beach, Fortesquue Beach, Villas Beach) that will utilize sand dredged from the Delaware Bay portion of the Delaware River Philadelphia to the Sea 45' Federal Navigation project (Figure 4). You anticipate using a bulldozer to push sand above the mean high tide line to create a temporary small berm along a small section of beach that is being nourished so that the effluent (sand and water mixture) being pumped onto that beach section doesn't flow back into the Bay and has more time to settle out and soak. This avoids most turbidity in the intertidal zone. However, once the pumping of sand concludes and the dredge outfall pipe is moved further down the beach, a bulldozer will come back and subsequently smooth out the temporary sand berm in the previous section. This phase of the work does occur in the beach/water interface, and may introduce minor turbidity to the nearshore waters of the Bay. Currently the only time of year restriction for DMU work is for sand placement: no sand placement shall occur from April 15 through June 7 to avoid impacts to migratory shorebirds.

You provided us information about the proposed dredging for the DMU study in an email sent July 18, 2018. All dredging will be conducted with a hopper dredge equipped with UXO screens (see description in section 3.7 below). Initial constructions at the Delaware beach restoration sites are expected to start in 2020 for Lewes Beach, Prime Hook Beach and Slaughter Beach and 2026 for Pickering Beach, Kitts Hummock, Bowers Beach and South Bowers Beach. The initial construction at the New Jersey sites is expected to start in 2022 for the Gandys Beach and Fortescue and 2028 for the Villas South site. You will use a total of approximately 2,780,000 cubic yards of dredged sand for the initial construction of the two sites (Table 1). Following initial construction, you will conduct periodic beach nourishment with approximately 400,000 cubic yards of sand at the Delaware sites and 180,000 cubic yards of sand at the New Jersey sites every six years. Periodic beach nourishment will occur until 2068 for the Delaware sites and until 2070 for the New Jersey sites. Thus, it is expected that seven periodic beach nourishment events will occur at the two sites with the dredging and placement of a total of approximately 4,060,000 cubic yards of dredged material.



DELAWARE	
ID	Name
D9	Pickering Beach
D10	Kitts Hummock
D11	Bowers Beach
D12	South Bowers
D15	Slaughter Beach
D17	Prime Hook Beach
D18	Lewes Beach

NEW JERSEY	
ID	Name
N22	Gandy's Beach
N23	Fortescue
N33	Villas (South)

Figure 4. Map of DMU site locations.

3.4 Philadelphia to Trenton Maintenance Dredging

The Philadelphia District keeps the Delaware River ports, which includes Port of Bucks County and Tioga Marine Terminal, economically viable by maintaining an authorized 40-foot depth in the Delaware River navigation channel from Allegheny Avenue in Philadelphia (RKM 176.9) to Newbold Island in Bucks County (RKM 191.3), north of Philadelphia. From there, the District maintains the authorized 35-foot depth channel currently to a 25-foot depth just upstream (RKM 212.5) of Trenton Marine Terminal located in Trenton, NJ. The remaining authorized portion of the project, authorized to a 12-foot depth channel continues to the upstream limit of the project (RKM 214.5) just below the Penn-Central R.R. Bridge crossing the Delaware River at Trenton, NJ. The 12-foot authorized channel is currently not maintained by the PCOE and no dredging is likely to occur in the foreseeable future.

There are wide variations in the amount of dredging required to maintain the Philadelphia to Trenton navigation channel, with the largest percent of dredging occurring in the upper reach of the Delaware River, Philadelphia to Trenton 40-foot/35-foot channels. Historical records show 1,497,331 cubic yards (cy) of dredge material was removed cumulatively within the Philadelphia to Trenton project area between 1997 and 2008. Of that, approximately 27 percent of the material was removed from in-and-around the Fairless Turning Basin within the upper reach of the Delaware River, Philadelphia to Trenton 40-foot channel, with the remaining removed from spot shoal locations throughout the rest of the project area. The lower reach of the Delaware River, Philadelphia to Trenton 40-foot channel historically requires the least amount of dredging with an estimated 200,000 cy of dredge material removed every two years dependent upon funding and/or storm events. Maintenance dredging in the river usually takes place over an approximately two-month period between August and December by using either a hydraulic cutterhead dredge, bucket dredge or in some reaches conducted by the Federally-owned hopper dredge McFarland. The project location, size of disposal area and quantity of dredge material removed are factors that determine the type of dredge utilized during dredging. The timing, duration and exact location of maintenance dredging within the Philadelphia to Trenton project area varies but historically dredging is usually performed in alternating reaches rather than in its entirety with only shoal spots or shallow areas being targeted.

Money Island and Biles Island disposal areas (PADEP) have been utilized historically for the placement and disposal of authorized dredged material from within the upper reaches of the project limits; with Palmyra Cove (NJDEP) being utilized for dredged material from the lower reach of the Philadelphia to Trenton 40-foot channel. Currently NJDEP is working together with the New Jersey Department of Transportation (NJDOT) and you to reactivate two formally used upland sites (Burlington Island and Disposal Area #8 in Cinnaminson, NJ) along the lower reach of the 40-foot channel for placement of dredged material.

3.4.1 Maintenance Dredging of the Lower Reach of the Philadelphia to Trenton Project

Future maintenance dredging within the lower reach (Figure 5) will be completed to a required depth of 40’ Mean Lower Low Water (MLLW) plus 1’ allowable over-depth, limited by a vertical plane through the 40’ contour, from outside station 0+000 (Harbor Range) to station 88+895 (Bristol Range – upper end of Burlington Island, NJ), with required dredging limits extended 25’ outside of both channel edges (box cut). Approximately 200,000 cy of median to coarse grained sand are expected to be removed during a dredge cycle every two years dependent upon available funding, storm activity and/or emergency situations. Dredging will be completed by hydraulic dredging, bucket dredging, or hopper dredge and transported to either Fort Mifflin or Palmyra Cove for containment. Due to the small size of the disposal areas provided by the State of New Jersey, dredging will be performed by either hopper dredge or bucket dredge until which time that additional upland disposal sites can be reactivated as stated above. A typical dredging cycle is expected to last 30 days for hopper dredging and 60 days for bucket dredge.

Figure 5: Lower Reach of the Philadelphia to Trenton Project

3.4.2 Maintenance Dredging of the Upper Reach of the Philadelphia to Trenton Project

Maintenance dredging within the upper reach (Figure 6) will be completed within three portions that make up the Philadelphia to Trenton project area limits. Future dredging will be completed by pipeline dredge in accordance to the following dredging limits:

- 40’ depth channel upper reach limits: Station 87+895 to Station 124+677; 40’ MLLW + 1’ over-depth, limited by a vertical plane through the 40’ contour, with dredging limits extended 25’ outside of both channel edges (box cut).

- 25’depth channel limits: Station 124+677 to Station 153+040; 25’ MLLW + 1’ over-depth, limited by a vertical plane through the 25’ contour, with dredging limits extended 25’ outside of both channel edges (box cut).

- Fairless Turning Basin: 40’ MLLW + 1’ over-depth, with dredging limits extended 25’ outside of the basin’s boundaries with no side slopes delineated.

Approximately 500,000 cy of silt, clay, and sand are expected to be removed during a dredge cycle every 2 to 3 years dependent upon available funding, storm activity and/or emergency situations. Two upland disposal areas (Money Island and Biles Island) are provided by the Commonwealth of Pennsylvania for the disposal of dredged material generated by authorized dredging activities within the upper reach of the Delaware River. The last regular dredging cycle within the upper reach of the Delaware River, Philadelphia to Trenton project was complete on December 3, 2009.

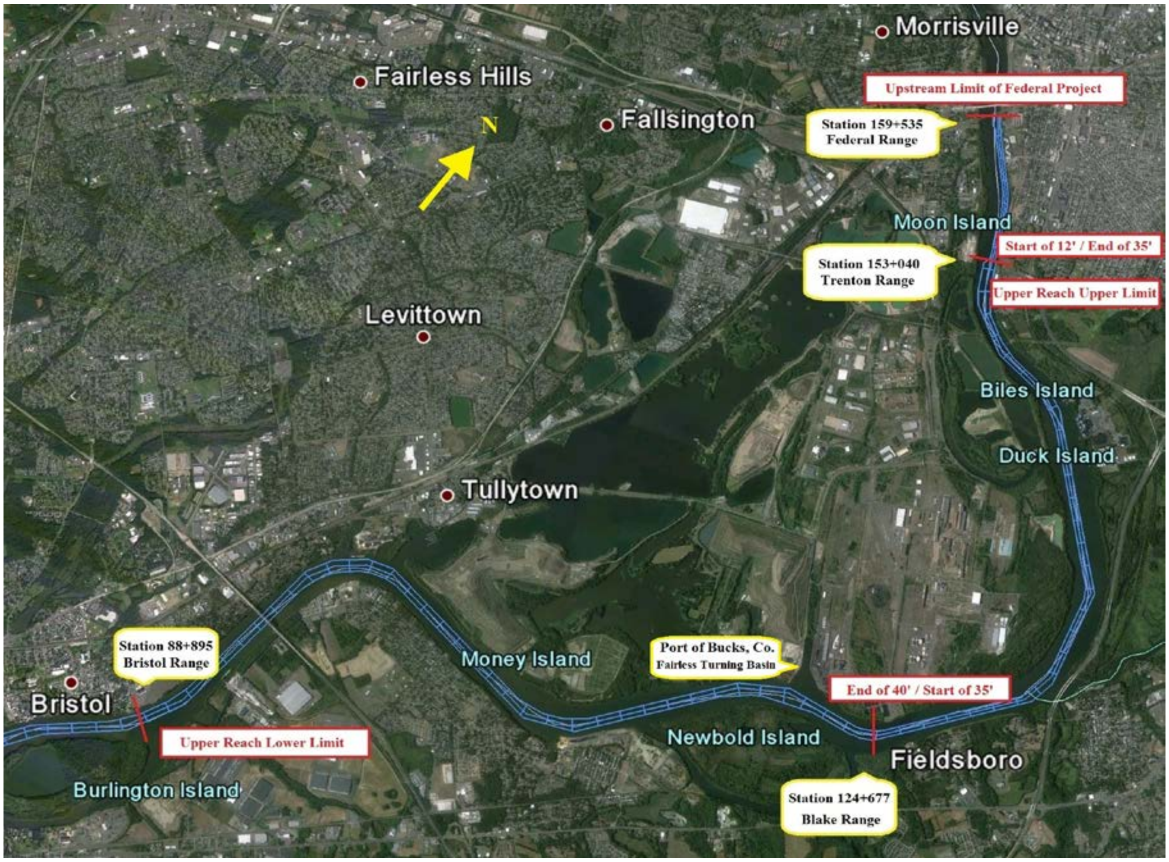


Figure 6. Upper Reach of the Philadelphia to Trenton Project.

3.4.3 Emergency Dredging of the Upper Reach of the Philadelphia to Trenton Project

Emergency dredging within the upper reach as shown above in Figure 3 was completed between October 11, 2013 on November 29, 2013. Dredging was completed by Norfolk Dredging Company utilizing a hydraulic pipeline dredge in accordance to the following authorized dredging limits:

- Bristol Range – Newbold Range: Station 87+895 to Station 122+600; 40' MLLW + 1' over-depth, limited by a vertical plane through the 40' contour, with dredging limits extended 25' outside of both channel edges (box cut).

- Duck Island Range: Station 142+500 to Station 144+675; 22' MLLW + 1' over-depth, limited by a vertical plane through the 40' contour, with dredging limits extended 25' outside of both channel edges (box cut).

- Fairless Turning Basin: 40' MLLW + 1' over depth, with no side slopes delineated for along the basin's east and west berthing lane edges; west channel edge of Newbold Range (box cut); dredging limits extended 25’ outside three remaining edges with no side slopes delineated; dredged as one acceptance section.

Approximately 541,381 cy of dredged material consisting of silt, clay, and sand was transported between two authorized upland disposal areas (Money Island and Biles Island). No sturgeon were observed during the emergency dredging operations.

3.4.4 Marcus Hook Range Lights

The project, to be carried out by the U.S. Coast Guard (or their contractors), involves replacing the existing Marcus Hook Range Lights along the Delaware River. The USCG has awarded a contract and construction is anticipated to start in 2019.

Because work will occur within the river, it has the potential to impact Atlantic and shortnose sturgeon, as well as Atlantic sturgeon critical habitat. We provided a list of threatened and endangered species that may be within the project area to the USCG on March 10, 2017. While we coordinated with USCG we learned the purpose of the proposed action is to reposition the range structures as a result of the USACE Delaware River channel dredging and deepening project. Under the Endangered Species Act (ESA) Section 7, interrelated actions are those that are part of a larger action and depend upon the larger action for their justification (50 CFR 402.02). Therefore, together with you and USCG, we determined that this activity is an interrelated activity of the Delaware River deepening, and it is considered in this Opinion.

Relocating the range lights and updating the optics will dramatically improve the performance of the navigational range within the Delaware River. In order to provide a safe navigation range line that satisfies channel requirements and present-day vessel characteristics, the proposed towers must be placed in a new location. The new structures with the updated optics will properly balance the day- and nighttime functions of the range structures and give an improved cross track error for mariners navigating within the Marcus Hook Bar.

The proposed activity includes the removal of one existing and the installation of two new USCG Aids-to-Navigation range lights used for the Marcus Hook navigation channel. The existing Front Range Light (FRL) structure has reached the end of its useful life and requires replacement. The existing Rear Range Light (RRL) structure is located in a lighthouse on private property in a residential neighborhood and is proposed to be taken out of service.

The project involves the removal of the existing FRL structure and the installation of two new range lights within the Delaware River. The proposed FRL and RRL structures will be located within the Delaware River. The proposed FRL will be located at the coordinates 39.77795 N, -75.471431 E (N39 46 40.6221, W075 28 17.1507), and the proposed RRL will be placed at the coordinates 39.775179 N, -75.477031 E (N39 46 30.6448, W075 28 37.3117).

At both sites, there is a layer of soft material that sits directly on bedrock. At the FRL, the soft material extends from the riverbed at elevation -17' to the top of bedrock, elevation -45'. The soft material layer extends from the riverbed at elevation +1' to the top of bedrock at elevation -35' at the RRL.

The proposed new FRL and RRL will each consist of a monopile structure equipped with a boat landing consisting of a ladder and small deck, and a 289-square foot service platform that will house solar panels, a small crane, and a battery building. The RRL will also include a steel tower and upper platform containing the optics. The optics of the FRL will be housed on the main platform. Each structure will also include a raptor platform for the nesting of osprey. Each raptor platform will consist of steel framing and fiberglass grating. The platform will be at the highest point of each structure, designed to prevent debris on the structure, and orientated so as to not interfere with the optics, equipment huts, or solar panels.

Permanent impacts to the Delaware River will be localized to the two proposed monopile locations. The following is an anticipated construction sequence for the project. The contractor will mobilize a barge with associated barge-mounted equipment to the site. The construction barge will be secured on-site by installing temporary piles. After verifying field conditions, the contractor will begin construction of the two new range light structures. The RRL is accessible by barge during high tide only. The new range light structures' designs leverage contemporary construction capabilities to significantly reduce environmental impacts by providing a single pile installation compared to the existing multi-pile structure. It is expected that there will be 20 square feet of permanent bottom impact at each of the proposed range light sites. The installation of each structure will consist of drilling a 60-inch diameter steel socket into the bedrock for the installation of a 48-inch steel monopile. It is anticipated the contractor will utilize a vibratory and/or impact hammer. USCG will require the contractor to drill slowly with low impact for the first ten minutes of drilling (i.e., soft start), to provide sturgeon an opportunity to leave the area before drilling reaches maximum capacity. Soil and rock will be excavated and removed from within the steel socket to facilitate placement of the monopile caisson. Soil will be removed to bedrock depth. Excavation equipment used to remove the soil and rock at the two monopile locations will include auger bits that will flush out rock and soil. Bedrock will then be drilled into in order to install the monopile structures. Approximately 30 cubic yards of soil and rock will be excavated from the FRL location and 40 cubic yards of soil and rock will be excavated and removed from the RRL location. Soil and rock material will be disposed of at an approved upland disposal site. The steel socket or casing that will be installed into the mudline and bedrock will help to minimize sediment plume size and disturbance within the action area.

Upon completion of the new FRL and RRL structures, the contractor will begin removal of the existing FRL structure. The existing FRL will be removed in its entirety. The existing FRL steel tower, concrete deck, and steel and timber framing components will be removed and disposed of at a suitable upland disposal site in accordance with applicable local, state, and federal regulations. The supporting timber piles will be fully extracted, if feasible; however, if they break during removal, they will be cut off at the mudline to eliminate any navigational hazards. Details of the existing FRL are shown on Sheet 4 of Enclosure B. The total volume of material to be removed below the mean high water (MHW) associated with demolition of the existing FRL is estimated to be 128 cubic yards.

An existing submerged electric cable is connected to an inland transmission pole to service power to the navigation light on the FRL. The power for the FRL originates at a transmission pole at 39.375102 N, -75.481622 E along U.S. Highway 13. The electrical transmission cable is approximately 6 inches in diameter and originates from an electrical meter along the left bank of Stoney Creek and extends along Stoney Creek 2,250 feet (0.426 nil) into the Delaware River to the FRL. Of the existing 2,250 feet of electric cable, divers will remove a total length of 20 linear feet by hand to a depth of 2 feet below the mudline. The cable will be removed from the point where it comes out of the water at the existing FRL, 10 feet back. At the other end, it will be removed from the edge of Stoney Creek, 10 feet into the water. The onshore portion, from the water's edge back to the pole, will also be removed. The remaining submerged electric cable will be abandoned and remain in place to avoid disturbance of the substrate. The total volume of material impacted below MHW associated with the cable removal is 3 cubic yards, consisting of both the cable to be removed and the disturbance to the riverbed.

In its letter dated April 6, 2017, the Delaware Department of Natural Resources and Environmental Control (DNREC) recommended a timing restriction from March 15 to June 30 for any in-water activity associated with pounding to avoid disturbing anadromous species. However, to minimize potential effects to early life stages of Atlantic sturgeon, USCG agreed to abide by a time of year restriction from March 16 – July 31 (email sent October 2, 2017). Therefore, work associated with installing the temporary piles for the barge(s), the steel sockets, and monopiles into the bedrock will not occur during that time. Additionally, any pounding activity associated with the removal of the existing FRL will not be conducted during that time. USCG anticipates that the installation of the new monopoles and associated equipment will take approximately 15 days at both the FRL and RRL locations.

It is anticipated that the proposed work will be completed by a standard barge or jack-up barge. A tug boat will move the barge from site to site. One or two barges will likely be used. A skiff will transport the construction crew to the construction site each work day. The crew will work at the new construction sites first, and then will move to the existing range light for the demolition work. Specifications of the barge and travel routes for the barge(s) and crew skiff have not been developed. However, the barge and skiff will travel to the site within designated channels that currently handle a substantial amount of traffic.

Upon completion of the work, the contractor will remove the temporary piles and barge, all construction materials, and associated equipment from the site. All construction debris will be appropriately removed from the site.

The contractor will be required to follow Best Management Practices for erosion and sediment control during construction. A debris boom/turbidity curtain will be installed by a small boat around each new range light location, as well as the existing range light location to ensure that debris does not leave the construction site. The debris boom/turbidity curtain will encompass an approximate area of 2500 square feet at each barge setup location.

3.5 Description of Dredge/Blasting Equipment

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

3.5.1 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 dredged material solids settle out from the water/solid slurry mixture and the supernatant water overflows the hopper. When the hopper load is full, the vessel suspends dredging, the dragarms are heaved aboard, and the dredge travels to the dredge material disposal site.

Use of UXO Screens

The United States Army Environmental Command (USAEC) defines unexploded ordinance (UXO) or munitions of explosive concern (MEC) as military munitions that have been (1) primed, fused, armed or otherwise prepared for action; (2) fired, dropped, launched, projected, or placed in such a manner to constitute a hazard to operations, installations, personnel, or material, and (3) remain unexploded either by malfunction, design, or any other case. UXO/MEC comes in many shapes and sizes, may be completely visible or partially or completely buried, and may be easy or virtually impossible to recognize as a military munition. UXO/MEC can be found in the ocean and may look like a bullet or bomb, or be in many pieces, but even small pieces of UXO/MEC can be dangerous. If disturbed, (touched, picked up, played with, kicked, thrown, etc.) the UXO/MEC may explode without warning, resulting in serious injury or even death. The borrow areas considered here occur in an area associated with past and current military activities and has revealed UXO/MEC during dredging operations.

The presence of UXO in dredged material presents two unique challenges. First, it poses a potential safety hazard to dredging or observer personnel and potential damage to the equipment and vessel. Second, any subsequent beneficial use of dredged material must also address the possibility of the presence of UXO and/or its removal.

Due to the possibility of encountering MEC or UXO within the lower Delaware Bay, screening is required on all dredges for beach nourishment projects by the USACE Philadelphia District. Beginning in 2007, dredges are now outfitted with 1) a screening device placed on the dredge intake or in a pipeline section prior to reaching the dredge pump, and 2) a screen (beach basket) at the discharge end of the pipeline on the beach. The purpose of the screening is to prevent ordnances from being deposited on the beach by dredging. The screening device on the dredge intake prevents the passage of any material greater than 1.25 inches in diameter. The maximum allowable opening size is 1.25 inches by 6 inches. The screening device on the discharge end (on the beach) consists of a 15' x 15' cage placed around the discharge pipe and is designed to retain all items 0.75 inches in diameter and larger. Visual inspection of the screens and sand placement are performed at all times while material is being placed on the beach. Assuming the use of a Hopper dredge, visual inspections of the interior and exterior of the beach basket are performed after each in-flow cycle.

3.5.2 Bucket Dredges

The bucket dredge is a mechanical device that utilizes a bucket to excavate dredge material. 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.

The opening of the bucket is controlled by the closing and hoisting wires or by hydraulic cylinders. The bucket is lowered into the water and is opened to grab the substrate. Only a small area is impacted at any given time and the bucket is lifted up and emptied between each grab.

3.5.3 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.

Cutterhead suction dredges are equipped with a rotating cutterhead, which is able to cut hard soil or rock into fragments. The cutter head is a rotating mechanical device, mounted in front of the suction head and rotating along the axis of the suction pipe. The cutterhead buries into the bottom and the substrate is sucked in by dredge pumps. The dredged material is sucked in as a solid/water slurry and pumped to the disposal site using pumps and a floating pipeline or is loaded onto a barge.

Rock Blasting

The presence of the bedrock within the Delaware River was evaluated through several investigations. These investigations included geophysical surveys, electrical resistivity surveys and geotechnical drilling investigations, to delineate the horizontal extent of the bedrock. The results of the combined investigations identified approximately 17 locations within Reach B, which would require rock removal via blasting as part of the dredging program.

Removal of bedrock (production blasting) to deepen the navigation channel to a depth of 45 feet occurred over the course of three previous blasting seasons (2015-2016, 2016-2017, and 2017-2018). The last removal of bedrock completed in 2018 was covered by the 2017 Opinion, and no production blasting of bedrocks remains.

However, following conventional dredging, you identified additional small rock outcrop areas along the west side of the channel within Reach B which will require blasting (Station 99+000 to Station 119+500 and Station 132+000 to 155+000). Therefore, you propose to remove approximately 25,000 cubic yards of rock over approximately 20 acres between RKM 125.5 and RKM 135.2 through blasting and mechanical removal. This work will include continued adherence to the NMFS approved sturgeon protection plan, including trawling and relocation. This additional blasting work is intended to remove unanticipated pinnacles of rock in the channel, as opposed to production blasting that occurred in the previous three seasons. Blasts are proposed to be much smaller in magnitude in order to target specific sites and rock outcrops. Approximately 80 to 100 holes were drilled for large production blasts previously, and 50 to 60 holes for smaller production blasts. For removal of the remaining rock pinnacles, it is estimated that 20-30 holes would be drilled per blast. A fourth year of blasting and explosives constitutes a modification to the action that was not considered in the 2017 Biological Opinion. Blasting will occur over approximately 30 days between December, 1, 2018 and March 15, 2019, or between December 1, 2019 and March 15, 2020, depending on funding. You propose to conduct on average two to three blasts per day.

In order to remove the rock by blasting, holes drilled into the rock will be packed with explosive at the bottom of the holes and the remainder of the drill-hole filled with inert stemming material to the surface in order to direct the force of the blast into the rock. The depth and placement of the holes along with the size and blast timing delays of the charges will be carefully controlled so that the amount of rock that is broken and energy levels released during the blasting operations is limited to the level required only to break up the bedrock. The project would be conducted by repeatedly drilling, blasting, and excavating relatively small areas until the required cross section of bedrock is removed.

The broken and pulverized rock along with overlying sands and silts will be removed by a mechanical dredge. If all the rock is not mechanically removed by March 15, 2019, the remaining rock will be mechanically removed between July 1, 2019, and March 15, 2020, or July 1, 2020, and March 15, 2021. Material will be placed either at the Fort Mifflin CDF or at various approved artificial reef sites in the Delaware Bay. We completed an informal consultation on your issuance of a permit to the Delaware Department of Natural Resources and Environmental

Control for their artificial reef program and associated material placement on June 1, 2018. Thus, the use and placement of dredged material on these sites will not be considered further here. Because the rock that will be blasted is bedrock, the areas that undergo blasting will retain the same substrate characteristics following the completion of this project.

USACE has built several measures into the proposed action designed to minimize the effects of blasting on fish (see Table 3). Specifically, relocation trawling will be initiated in mid-November 2018 approximately two weeks prior to the anticipated start of blasting operations (earliest start date for blasting is December 1, 2018). Initial trawling efforts will attempt to remove as many sturgeon as possible from the blasting area. Trawling will be performed every other day during blasting to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver. The acoustic deterrent system will be an Applied Acoustic Engineering Ltd. (AAE) “boomer” that will produce a low frequency sound of less than or equal to 204 dB re1µPa peak at a repetition of 20 booms per minute for at least 5 hours prior to each detonation. For more details on relocation and acoustic deterrence, see Sections 3.5.1 and 3.5.2.

For each blast, you propose to monitor an area with a radius of 500 feet surrounding the detonation site with sonar or other imaging techniques designed to document fish in this area. Surveys will begin 20 minutes prior to the blast and if any fish are observed in the monitoring zone, blasting will be delayed until the fish leave the area. Additionally, two scare charges shall be used before each blast. The scare charges shall be detonated in close proximity to each blast. Each individual scare charge shall not exceed a TNT-equivalent weight of 0.1 lb. The detonation of the first scare charge will be 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. You will also monitor blast pressures and upper limits so that blast pressures remain below 206 dB at a distance of 500 feet.

4.0 STATUS OF LISTED SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

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

We have determined that the action being considered in this biological opinion may affect the following endangered or threatened species and critical habitat under our 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
North Atlantic DPS of green sea turtle (*Chelonia mydas*)	Endangered/Threatened

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

Critical Habitat:
New York Bight DPS of Atlantic sturgeon (Delaware River Unit)

This section will focus on the status of the species and critical habitat 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

Leatherback and Kemp's ridley sea turtles are listed throughout their range while loggerhead and green sea turtles are listed as DPSs (one DPS of each species occurs in the action area). Information on the range-wide status of leatherback and Kemp's ridley sea turtles is included to provide the status of each species overall. Information on the status of loggerheads and greens 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 (Conant *et al.* 2009, NMFS and USFWS 2007a, NMFS and USFWS 2007b, c, d, Seminoff *et al.* 2015, TEWG 2000, 2007, 2009), and recovery plans for the loggerhead sea turtle (NMFS and USFWS 2008), Kemp's ridley sea turtle (NMFS *et al.* 2011), green sea turtle (NMFS and USFWS 1991), and leatherback sea turtle (NMFS and USFWS 1998).

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. This extensive oiling event contaminated important sea turtle foraging, migratory, and breeding habitats at the surface, in the water column, on the ocean bottom, and on beaches throughout the northern Gulf of Mexico in areas used by different life stages. Sea turtles were exposed to oil when in contaminated water or habitats; breathing oil droplets, oil vapors, and smoke; ingesting oil-contaminated water and prey; and potentially by maternal transfer of oil compounds to embryos (DWH NRDA Trustees 2016). Response activities and shoreline oiling also directly injured sea turtles and disrupted or deterred sea turtle nesting in the Gulf.

During direct at-sea capture events, more than 900 turtles were sighted, 574 of which were captured and examined for oiling (Stacy 2012). Of the turtles captured during these operations, greater than 80 percent were visibly oiled (DWH NRDA Trustees 2016). Most of the rescued turtles were taken to rehabilitation facilities; more than 90 percent of the turtles admitted to rehabilitation centers eventually recovered and were released (Stacy 2012). Recovery efforts also included relocating nearly 300 sea turtle nests from the northern Gulf to the east coast of Florida in 2010, with the goal of preventing hatchlings from entering the oiled waters of the northern Gulf. Approximately 14,000 hatchlings were released off the Atlantic coast of Florida, 95 percent of which were loggerheads (http://www.nmfs.noaa.gov/pr/health/oilspill/gulf2010.htm).

Direct observations of the effects of oil on turtles obtained by at-sea captures, sightings, and strandings only represent a fraction of the scope of the injury. As such, the DWH NRDA Trustees used expert opinion, surface oiling maps, and statistical approaches to apply the directly observed adverse effects of oil exposure to turtles in areas and at times that could not be surveyed. The Trustees estimated that between 4,900 and up to 7,600 large juvenile and adult sea turtles (Kemp's ridleys, loggerheads, and hardshelled sea turtles not identified to species), and between 55,000 and 160,000 small juvenile sea turtles (Kemp's ridleys, green turtles, loggerheads, hawksbills, and hardshelled sea turtles not identified to species) were killed by the DWH oil spill (DWH NRDA Trustees 2016). Nearly 35,000 hatchling sea turtles (loggerheads, Kemp's ridleys, and green turtles) were also injured by response activities. Despite uncertainties and some unquantified injuries to sea turtles (e.g., injury to leatherbacks, unrealized reproduction), the Trustees conclude that this assessment adequately quantifies the nature and magnitude of injuries to sea turtles caused by the DWH oil spill and related activities.

Based on this quantification of sea turtle injuries caused by the DWH oil spill, sea turtles from all life stages and all geographic areas were lost from the northern Gulf of Mexico ecosystem. The DWA NRDA Trustees (2016) conclude that the recovery of sea turtles in the northern Gulf of Mexico from injuries caused by the DWH oil spill will require decades of sustained efforts to reduce the most critical threats and enhance survival of turtles at multiple life stages. The ultimate population level effects of the spill and impacts of the associated response activities 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.

On September 22, 2011, we issued a final rule with USFWS (76 FR 58868), determining that the loggerhead sea turtle is composed of nine DPSs (as defined in as defined in as defined in as defined in as defined in as defined in as defined in as defined in Conant *et al.* 2009) that constitute species that may be listed as threatened or endangered under the ESA. Five DPSs were listed as endangered (North Pacific Ocean, South Pacific Ocean, North Indian Ocean, Northeast Atlantic Ocean, and Mediterranean Sea), and four DPSs were listed as threatened (Northwest Atlantic Ocean, South Atlantic Ocean, Southeast Indo-Pacific Ocean, and Southwest Indian Ocean). Note that the Northwest Atlantic Ocean (NWA) DPS and the Southeast Indo-Pacific Ocean DPS were originally proposed as endangered. The NWA DPS was determined to be threatened based on review of nesting data available after the proposed rule was published, information provided in public comments on the proposed rule, and further discussions within the agencies. The two primary factors considered were population abundance and population trend. We found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats. This final listing rule became effective on October 24, 2011.

The September 2011 final rule also noted that critical habitat for the two DPSs occurring within the U.S. (NWA DPS and North Pacific DPS) would 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. On July 10, 2014, the USFWS and NMFS published two separate final rules in the Federal Register designating critical habitat for the NWA DPS of loggerhead sea turtles under the ESA (79 FR 39755 for nesting beaches under FWS jurisdiction; 79 FR 39856 for marine areas under NMFS jurisdiction). Effective August 11, 2014, NMFS's final rule for marine areas designated 38 occupied areas within the at-sea range of the DPS. These recently designated marine areas of critical habitat contain one or a combination of: nearshore reproductive habitat, overwintering habitat, breeding habitat, migratory habitat, and *Sargassum* habitat.

The only DPS that occurs in the action is the Northwest Atlantic DPS. None of the critical habitat designated for loggerhead sea turtles occurs in the action area.

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 2007d), 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 (Ehrhart *et al.* 2003, Mitchell *et al.* 2002, Shoop and Kenney 1992). 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 (Braun-McNeill *et al.* 2008, Epperly 1995a, b, Mitchell *et al.* 2002, Shoop and Kenney 1992). Loggerheads have been observed in waters with surface temperatures of 7°C to 30°C, but water temperatures ≥11°C are most favorable (Epperly 1995a, Shoop and Kenney 1992). 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 (Blumenthal *et al.* 2006, Braun-McNeill and Epperly 2004, Hawkes *et al.* 2006, Mansfield 2006, Mansfield *et al.* 2009, McClellan and Read 2007, Mitchell *et al.* 2002).

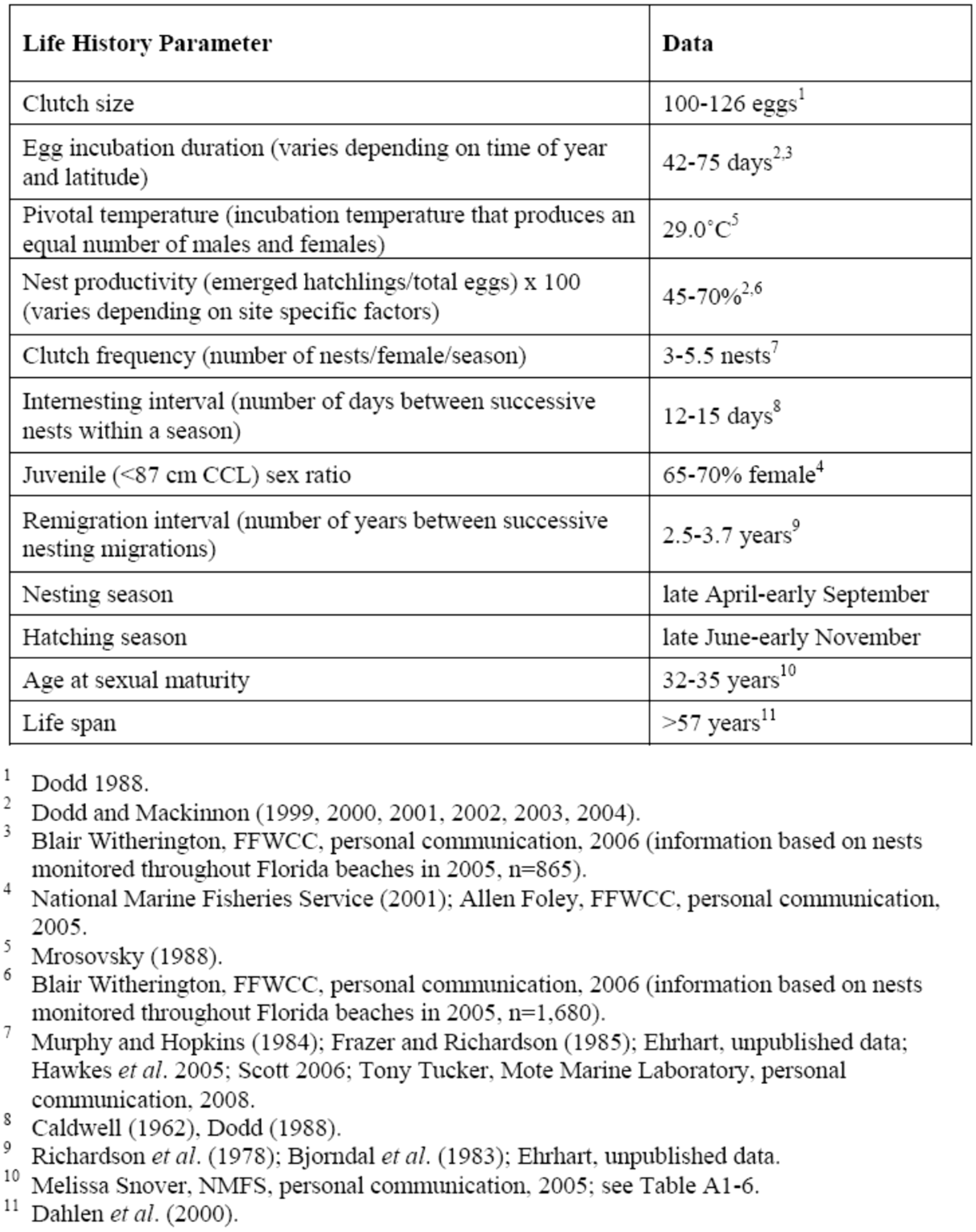
Loggerhead sea turtles occur year round in ocean waters off North Carolina, South Carolina, Georgia, and Florida. In these areas of the South Atlantic Bight, water temperature is influenced by the proximity of the Gulf Stream. As coastal water temperatures warm in the spring, loggerheads begin to migrate to inshore waters of the Southeast United States (*e.g.*, Pamlico and Core Sounds) and also move up the U.S. Atlantic coast (Braun-McNeill and Epperly 2004, Epperly 1995a, b, c), 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 (Epperly 1995b, Shoop and Kenney 1992).

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 (Blumenthal *et al.* 2006, Hawkes *et al.* 2006, Mansfield *et al.* 2009, McClellan and Read 2007, Wiltzell *et al.* 2002). 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 4 from the 2008 loggerhead recovery plan (Table 4 in this Opinion) highlights the key life history parameters for loggerheads nesting in the United States.

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



Life History Parameter	**Data**
Clutch size	100-126 eggs[1]
Egg incubation duration (varies depending on time of year and latitude)	42-75 days[2,3]
Pivotal temperature (incubation temperature that produces an equal number of males and females)	29.0°C[5]
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70%[2,6]
Clutch frequency (number of nests/female/season)	3-5.5 nests[7]
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 2007d). 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 (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 Loggerhead 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.* 2009b). 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.* (2009a), 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 percent decrease in annual nest counts from index beaches, which represent an average of 70 percent of the statewide nesting activity (NMFS and USFWS 2008). From 1989-2008, the PFRU had an overall declining nesting trend of 26 percent (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 percent 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 percent 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 percent 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 2007d). 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 (Bass *et al.* 2004, Bowen *et al.* 2004, Rankin-Baransky *et al.* 2001, Wiltzell *et al.* 2002). 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 (Ehrhart *et al.* 2007, Epperly *et al.* 2007, Maier *et al.* 2004, Mansfield 2006, Morreale *et al.* 2005). 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 (Anonymous 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 percent reduction in densities during the spring residency period and a 74.9 percent 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 (Anonymous 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 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 percent (5%-11% inter-quartile range) median surface time in the South Atlantic area and a 67 percent (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 (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 percent were seen south of Cape Hatteras, North Carolina, 30 percent in the southern Mid-Atlantic Bight, and 6 percent 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.

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 2007d, 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 2007d, 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 (Finkbeiner *et al.* 2011, NRC 1990). 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, Lewison *et al.* 2003). The 2002 section 7 consultation on the U.S. South Atlantic and Gulf of Mexico shrimp fisheries 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 2002).

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 were 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 percent 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 were projected in the 2002 Opinion. In 2008, the NMFS Southeast Fisheries Science Center (SEFSC) estimated annual number of interactions between loggerheads and shrimp trawls in the Gulf of Mexico shrimp fishery to be 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). However, the most recent section 7 consultation on the shrimp fishery, completed in May 2012, was unable to estimate the total annual level of loggerhead interactions at present. Instead, it qualitatively estimated that the shrimp fishery, as currently operating, would result in at least thousands and possibly tens of thousands of interactions annually, of which at least hundreds and possibly thousands are expected to be lethal (NMFS 2012).

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 five-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. Loggerhead bycatch in U.S. Mid-Atlantic bottom otter trawl gear has been previously estimated for the periods of 1996-2004 (Murray 2008) and 2005-2008 (Warden 2011a), with the most recent bycatch analysis estimating the number of loggerhead sea turtle interactions with U.S. Mid-Atlantic bottom trawl gear from 2009-2013 (Murray 2015). From 2009-2013, a total of 1,156 loggerheads (95% CI: 908-1,488) were estimated to have interacted with bottom trawl gear in the U.S. Mid-Atlantic, of which 479 resulted in mortality. The total number of estimated interactions was equivalent to 166 adults, of which 68 resulted in mortality (Murray 2015). That equates to an annual average of 231 loggerhead interactions (95% CI: 182-298) for the period of 2009-2013. The trawl fishery targeting Atlantic croaker in the southern Mid-Atlantic had the highest turtle interactions among fisheries investigated, which may be due to larger mesh sizes in the mouth of the trawl and high headline height of the gear. Murray (2015) found that retained catch, depth, latitude, and sea surface temperature (SST) were associated with the interaction rate, with the rates being highest south of 37°N latitude in warm, shallow (<50 meters deep) waters. This estimate is a decrease from the average annual loggerhead bycatch in U.S. Mid-Atlantic bottom otter trawls during the 1996-2004 and 2005-2008 time periods, which were estimated to be 616 (95% CI: 367-890) and 352 turtles (95% CI: 276-439), respectively (Murray 2008, 2015, Warden 2011b).

There have been several published estimates of the number of loggerheads interacting annually with 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) 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 (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 (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 (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 SST, depth, and use of a chain mat. Results from that analysis suggested that chain mats and fishing effort reductions contributed to the decline in estimated loggerhead sea turtle interactions with scallop dredge gear after 2006 (Murray 2011). A more recent analysis has indicated that the average annual observable sea turtle interactions in the Mid-Atlantic scallop dredge fishery plus unobserved, quantifiable interactions was 22 loggerheads per year (95% CI: 4-67), 9-19 of which were lethal (Murray 2015). The 22 interactions equate to two adult equivalents per year and 1-2 adult equivalent mortalities. Thus, estimated interactions in the scallop dredge fishery have decreased relative to 2001-2008, although the utility of observers as a monitoring tool for turtle interactions in the fishery seems to be decreasing (Murray 2015).

An estimate of the number of loggerheads interacting annually with U.S. Mid-Atlantic gillnet fisheries has also recently been published (Murray 2013). From 2007-2011, an annual average of 95 hard-shelled sea turtles (95% CI: 60-138) and 89 loggerheads (equivalent to nine adults) were estimated to have interacted with U.S. Mid-Atlantic gillnet gear. An estimated 52 annual loggerhead interactions (equivalent to five adults) were considered to result in mortality. Gillnet trips landing monkfish had the highest estimated number of loggerhead and hard-shelled sea turtle interactions during 2007-2011. Estimated rates and interactions have decreased relative to those from 1996-2006. Bycatch rates were correlated with latitude, SST, and mesh size. High interaction rates are estimated in the southern Mid-Atlantic, in warm surface temperature water, and in large-mesh gillnets; findings which are consistent with prior loggerhead bycatch analyses (Murray 2013).

The U.S. tuna and swordfish longline fisheries that are managed under the Highly Migratory Species (HMS) Fishery Management Plan (FMP) are estimated to capture 1,905 loggerheads (no more than 339 mortalities) for each three-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 2014). In 2014, there were 25 observed interactions between loggerhead sea turtles and longline gear used in the HMS fishery (Garrison and Stokes 2016). Of the observed interactions (25), all but one loggerheads were released alive, with 24 out of 25 (96%) released alove but injured. A total of 259 (95% CI: 165.3-405.6) loggerhead sea turtles were estimated to have interacted with the longline fisheries managed under the HMS FMP in 2014 based on the observed bycatch events (Garrison and Stokes 2016). Including the 2014 estimate, loggerhead interactions since 2000 have been well below the historical highs that occurred in the mid-1990s (Garrison and Stokes 2016). Generally, the period from 2009-2014 has lower overall estimates of loggerhead takes relative to previous cycles despite a generally increasing trend in fishing effort over time (Garrison and Stokes 2016). 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.

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. For a complete discussion of how global climate change may affect the NWA loggerhead DPS, see Section 6.0.

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 (NMFS and USFWS 2007d, 2008, NRC 1990). 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 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, NMFS and USFWS 2007c, Schmid and Witzell 1997, Snover *et al.* 2007). 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 1990, 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 Sea Turtle Stranding and Salvage Network (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 meters (NMFS and USFWS 2015). 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 2015).

Foraging areas documented along the U.S. Atlantic coast include Charleston Harbor, Pamlico Sound (Epperly 1995c), Chesapeake Bay (Musick and Limpus 1997), Delaware Bay (Stetzar 2002), and Long Island Sound (Morreale *et al.* 2005, Morreale and Standora 1994). 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 1995a, b, Musick and Limpus 1997).

Adult Kemp's ridleys are found in the coastal regions of the Gulf of Mexico and southeastern U.S., but are typically rare in the northeastern U.S. waters of the Atlantic (TEWG 2000). Adults are primarily found in nearshore waters of 68 meters or less (mean 33.2 ± 25.3 kilometers from shore) that are rich in crabs and have a sandy or muddy bottom (NMFS and USFWS 2015).

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 *et al.* 2011, NMFS and USFWS 2007c). There is a limited amount of scattered nesting to the north and south of the primary nesting beach (NMFS and USFWS 2015). 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 *et al.* 2011; NMFS and USFWS 2015). 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). From the mid-1980s to the early 2000s, the number of nests observed at Rancho Nuevo and nearby beaches increased 14-16 percent per year (Heppell *et al.* 2005), allowing cautious optimism that the population was on its way to recovery. The total number of nests for all of Mexico was 22,458 in 2012 (the highest nesting total recorded since 1947), but fell back to 16,944 in 2013 and 12,060 in 2014. Based on an average of 2.5 nests per female per nesting season (NMFS *et al.* 2011), the total number of nests on Mexico beaches represented about 8,984 nesting females in 2012, 6,778 in 2013, and 4,824 in 2014 (NMFS and USFWS 2015). Similar to Mexico, Texas also experienced an overall increase in the number of nests since 2000. At Padre Island National Seashore, the number of observed nests hit an all-time high of 209 in 2012, but then fell back to 153 in 2013 and 119 in 2014 (NMFS and USFWS 2015).

Threats

Kemp's ridley sea turtles 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 Kemp's ridleys that use the more northern habitats of Cape Cod Bay and Long Island Sound. From 2009-2013, the number of cold-stunned Kemp's ridleys on Massachusetts beaches averaged 185 turtles (NMFS unpublished data). The numbers ranged from a low of 132 in 2011 to a high of 235 in 2012. However, in 2014, the number of cold-stunned Kemp's ridleys documented in Massachusetts skyrocketed to 1,179, of which 466 died (NMFS unpublished data). As evidenced by this drastic increase, annual cold stun events can vary greatly in magnitude. The extent of episodic major cold stun events may be associated with numbers of sea 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 ridley sea turtles.

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 (NMFS and USFWS 1992a). 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 (Epperly 2003, Lewison *et al.* 2003, NMFS 2002). 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 2002).

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., 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. The most recent section 7 consultation on the shrimp fishery, completed in May 2012, was unable to estimate the total annual level of Kemp's ridley interactions occurring in the fishery. Instead, it qualitatively estimated that the shrimp fishery, as currently operating, would result in at least tens of thousands and possibly hundreds of thousands of interactions annually, of which at least thousands and possibly tens of thousands are expected to be lethal (NMFS 2002).

This species is also affected by other sources of anthropogenic impact (fishery and non-fishery related), similar to those discussed above. One Kemp's ridley capture in Mid-Atlantic trawl fisheries was documented by NMFS observers between 2009 and 2013 (Murray 2015), and five Kemp's ridleys were documented by NMFS observers in Mid-Atlantic sink gillnet fisheries between 2007 and 2011 (Murray 2013). Additionally, in the spring of 2000, 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 NEFSC 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 56 Kemp's ridleys (36 of which were found alive) impinged or captured on their intake screens from 1992-2011 (NMFS 2011).

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 seawater. 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 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, Hawkes *et al.* 2007, 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 shoreline is accreting, unlike much of the Texas coast, and with nesting increasing and sand temperatures slightly cooler than at Rancho Nuevo, Padre Island could become an increasingly important source of males for the population.

As with the other sea turtle species discussed in this section, while there is a reasonable degree of certainty that certain 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 predictable or quantifiable at this time (Hawkes *et al.* 2009). Based on the most recent five-year status review (NMFS and USFWS 2015), and following from the climate change discussion on loggerheads, it is unlikely that impacts from climate change will have a significant effect on the status of Kemp’s ridleys over the scope of the proposed action. However, significant impacts from climate change in the future are to be expected, but the severity of and rate at which these impacts will occur is currently unknown.

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 (NMFS and USFWS 2015). 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 (NMFS *et al.* 2011, TEWG 2000). However, the total annual number of nests at Rancho Nuevo gradually began to increase in the 1990s (NMFS and USFWS 2015). Based on an average of 2.5 nests per female per nesting season (NMFS *et al.* 2011), the total number of nests on Mexico beaches represented about 4,824 nesting females in 2014 (NMFS and USFWS 2015). 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 2015). 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 also contribute to annual human caused mortality, but the levels are unknown. Based on their five-year status review of the species, NMFS and USFWS (2015) determined that Kemp's ridley sea turtles should remain classified as endangered under the ESA. A revised bi-national recovery plan was published for public comment in 2010, and in September 2011, the NMFS, USFWS, 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 – North Atlantic DPS

Green sea turtles are distributed circumglobally, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters. They can be found in the Pacific, Indian, and Atlantic Oceans as well as the Mediterranean Sea (NMFS and USFWS 1995, NMFS and USFWS 2007b). Their movements within the marine environment are not fully understood, but it is believed that green sea turtles inhabit coastal waters of over 140 countries.

Listing History

The green sea turtle was originally listed under the ESA on July 28, 1978 (43 FR 32800). Breeding populations of the green sea turtle in Florida and along the Pacific coast of Mexico were listed as endangered; while all other populations were listed as threatened. The major factors contributing to its status at the time included human encroachment and associated activities on nesting beaches; commercial harvest of eggs, subadults, and adults; predation; lack of comprehensive and consistent protective regulations; and incidental take in fisheries. Marine critical habitat for the green sea turtle was designated on September 2, 1998, for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys (63 FR 46693).

On April 6, 2016, the NMFS and USFWS issued a final determination that the green sea turtle is comprised of eleven DPSs, constituting the "species," to be listed as threatened or endangered under the ESA (81 FR 20058). Effective May 6, 2016, three DPSs were listed as endangered, eight as threatened. The April 2016 final rule replaced the 1978 global listing of green sea turtles.

In the final ESA listing decision, the NMFS and USFWS listed eleven green sea turtle DPSs distributed globally: (1) North Atlantic (threatened), (2) Mediterranean (endangered), (3) South Atlantic (threatened), (4) Southwest Indian (threatened), (5) North Indian (threatened), (6) East Indian-West Pacific (threatened), (7) Central West Pacific (endangered), (8) Southwest Pacific (threatened), (9) Central South Pacific (endangered), (10) Central North Pacific (threatened), and (11) East Pacific (threatened) (81 FR 20058; April 6, 2016). Based on the best available scientific and commercial data, only one listed DPS is likely to occur in the action area, the threatened North Atlantic DPS. The range of the North Atlantic DPS extends from the boundary of South and Central America, north along the coast to include Panama, Costa Rica, Nicaragua, Honduras, Belize, Mexico, and the U.S. It extends due east across the Atlantic Ocean at 48°N and follows the coast south to include the northern portion of the Islamic Republic of Mauritania (Mauritania) on the African continent to 19°N. It extends west at 19°N to the Caribbean basin to 65.1°W, then due south to 14°N, 65.1°W, then due west to 14°N, 77°W, and due south to 7.5°N, 77°W, the boundary of South and Central America. It includes Puerto Rico, the Bahamas, Cuba, Turks and Caicos Islands, Republic of Haiti, Dominican Republic, Cayman Islands, and Jamaica. The North Atlantic DPS includes the Florida breeding population, which was originally listed as endangered under the ESA (43 FR 32800; July 28, 1978).

In regards to discreteness, North Atlantic DPS populations of green sea turtles exhibit minimal mixing with the adjacent South Atlantic DPS and no mixing with the adjacent Mediterranean DPS. Occasionally, juvenile turtles from the North Atlantic may settle into foraging grounds in the South Atlantic or Mediterranean, while adult turtles nesting at sites in the equatorial region of the North Atlantic may travel to, and reside at, foraging grounds in the South Atlantic. However, the reverse (i.e., turtles from the South Atlantic or Mediterranean DPS settling in North Atlantic waters) has yet to be documented. Furthermore, green sea turtles from the Mediterranean DPS appear to be spatially separated from populations in the Atlantic Ocean (Seminoff *et al.* 2015).

Distribution and Life History

Green sea turtles were once the target of directed fisheries in the U.S. and throughout the Caribbean. In 1890, over one million pounds of green sea turtles were captured 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 North Atlantic, large juvenile and adult green sea turtles are largely herbivorous, occurring in habitats containing benthic algae and seagrasses from Massachusetts to Central America, including the Gulf of Mexico and Caribbean (Wynne and Schwartz 1999). Green sea turtles occur seasonally in U.S. Mid-Atlantic and Northeast waters such as Chesapeake Bay and Long Island Sound (Morreale *et al.* 2005, Morreale and Standora 1998, Musick and Limpus 1997), which serve as foraging and developmental habitats.

Some of the principal feeding areas in the North 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 Fort 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, and the Caribbean coast of Panama (Hirth 1997).

Age at maturity for green sea turtles is estimated to be 20-50 years (Balazs 1995, Seminoff 2004). Adult females may nest multiple times in a season (average three nests/season with approximately 100 eggs/nest) and typically do not nest in successive years (Hirth 1997, NMFS and USFWS 1991).

Population Dynamics and Status

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 North Atlantic DPS contains an estimated 167,424 females nesting at 73 sites (81 FR 20058).

In 2015, the Green Turtle Status Review Team (SRT) identified those 73 nesting sites within the North Atlantic DPS, although some represent numerous individual beaches. There are four regions that support high density nesting concentrations for which data were available: Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, and Quintana Roo), U.S. (Florida), and Cuba. Nester abundance was assessed by the SRT for 48 nesting sites within the North Atlantic DPS. Abundance was estimated using the best scientific information available. Remigration intervals and clutch frequencies were used to estimate total nester abundance when counts of nesters were not available. In terms of nester distribution, the largest nesting site (Tortuguero, Costa Rica) hosts 79 percent of total nester abundance (167,528 nesters). There were also 26 nesting sites for which there were qualitative reports of nesting activity but no nesting data: three in the Bahamas, three in Belize, one in Costa Rica, four in Cuba, one in the Dominican Republic, one in Haiti, six in Honduras, two in Jamaica, one in Mauritania, one in Panama, and three in the Turks and Caicos Islands (Seminoff *et al.* 2015). Green turtle nesting populations in the North Atlantic are some of the most studied in the world, with time series exceeding 40 years in Costa Rica and 35 years in Florida. There are seven sites for which ten years or more of recent data are available for annual nester abundance.

By far, the most important nesting concentration for green sea turtles in the North Atlantic DPS is in Tortuguero, Costa Rica (Seminoff *et al.* 2015). This population has been studied since the 1950s and nesting has increased markedly since the early 1970s. From 1971 to 1975, there were approximately 41,250 nesting emergences per year and from 1992 to 1996 there were approximately 72,200 nesting emergences per year (Bjorndal 1997). From 1999 to 2003, about 104,411 nests/year were deposited, which corresponds to approximately 17,402-37,290 nesting females each year (Troëng and Rankin 2005). An estimated 180,310 nests were laid during 2010, the highest level of green sea turtle nesting estimated since the start of nesting track surveys in 1971. This equates to 30,052-64,396 nesters in 2010. This increase has occurred despite substantial human impacts to the population at the nesting beach and at foraging areas (Campbell and Lagueux 2005, Troëng and Rankin 2005). The number of females nesting per year on beaches in Mexico, Florida, and Cuba number in the hundreds to low thousands, depending on the site (Seminoff *et al.* 2015).

The status of the Florida breeding population was also evaluated in the 2015 status review (Seminoff *et al.* 2015). In Florida, nesting occurs in coastal areas of all regions except the Big Bend area of west central Florida. The bulk of nesting occurs along the Atlantic coast of eastern central Florida, where a mean of 5,055 nests were deposited each year from 2001 to 2005 (Meylan *et al.* 2006) and 10,377 each year from 2008 to 2012 (B. Witherington, Florida Fish and Wildlife Conservation Commission, pers. comm., 2013). Nesting has increased substantially over the last 20 years and peaked in 2011 with 15,352 nests statewide (Chaloupka *et al.* 2008). The estimated total nester abundance for Florida is 8,426 turtles.

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 U.S. (Seminoff *et al.* 2015). The statewide Florida index beach surveys (1989-2015) have shown that green sea turtle nest counts have increased almost one hundredfold since 1989, from a low of 267 to a high of 27,975 in 2015 (http://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/). The last three odd-numbered years (2011, 2013, and 2015) have all broken previous records for the highest numbers of green sea turtle nests on Florida's index beaches.

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.

Similar to the nesting trend found in Florida, in-water studies in Florida have also recorded increases in green sea turtle captures at the Indian River Lagoon site, with a 661 percent increase over 24 years (Ehrhart *et al.* 2007), and the St Lucie Power Plant site, with a significant increase in the annual rate of capture of immature green sea turtles (SCL<90 centimeters) from 1977 to 2002 or 26 years (`3,557 green sea turtles total; `3,557 green sea turtles total; `3,557 green sea turtles total; `3,557 green sea turtles total; `3,557 green sea turtles total; `3,557 green sea turtles total; `3,557 green sea turtles total; `3,557 green sea turtles total; Witherington *et al.* 2006).

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 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).

Incidental fishery mortality accounts for a large proportion of annual human-caused mortality outside the nesting beaches. Witherington *et al.* (2009b) observed 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 levels of interactions, green sea turtles have been observed captured in the pelagic driftnet, pelagic longline, southeast shrimp trawl, and Mid-Atlantic trawl and gillnet fisheries. Two green sea turtle captures in Mid-Atlantic trawl fisheries was documented by NMFS observers between 2009 and 2013 (Murray 2015), while Murray (2013) indicated that there were 12 observed captures of green sea turtles in Mid-Atlantic sink gillnet gear between 2007 and 2011.

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., 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. The most recent section 7 consultation on the shrimp fishery, completed in May 2012, was unable to estimate the total annual level of green sea turtle interactions occurring in the fishery. Instead, it qualitatively estimated that the shrimp fishery, as currently operating, would result in at least hundreds and possibly low thousands of interactions annually, of which hundreds are expected to be lethal (NMFS 2002).

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).

The most recent five-year status review for green sea turtles (Seminoff *et al.* 2015) notes that global climate change is affecting the species and will likely continue to be a threat. There is an increasing female bias in the sex ratio of green sea turtle hatchlings. While this is partly attributable to imperfect egg hatchery practices, global climate change is also implicated as a likely cause, as warmer sand temperatures at nesting beaches are likely to result in the production of more female embryos. Climate change may also impact 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 (Duarte 2002, Short and Neckles 1999).

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, due to a lack of scientific data, the specific future effects of climate change on green sea turtles are not predictable or quantifiable to any degree at this time (Hawkes *et al.* 2009). For example, information is not available 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 and the 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. Based on the most recent five-year status review (Seminoff *et al.* 2015), and following from the climate change discussions on the other hard-shelled sea turtle species, it is unlikely that impacts from climate change will have a significant effect on the status of green sea turtles over the scope of the action assessed in this Opinion. However, significant impacts from climate change in the future are to be expected, but the severity of and rate at which these impacts will occur is currently unknown.

Summary of Status for the North Atlantic DPS of Green Sea Turtles

In the North Atlantic, nesting groups are considered to be doing relatively well (i.e., the number of sites with increasing nesting are greater than the number of sites with decreasing nesting) (Seminoff *et al.* 2015). However, given the late age to maturity for green sea turtles, caution is urged regarding the status of nesting groups in the North Atlantic DPS since no area has a dataset spanning a full green sea turtle generation (Seminoff *et al.* 2015).

Seminoff *et al.* (2015) concluded that green sea turtle abundance is increasing for four nesting sites in the North Atlantic. They also concluded that nesting at Tortuguero, Costa Rica represents the most important nesting area for green sea turtles in the North Atlantic and that nesting at Tortuguero has increased markedly since the 1970s (Seminoff *et al.* 2015). However, the five-year status review also noted that the Tortuguero nesting stock continues to be affected by ongoing directed captures at their primary foraging area in Nicaragua. The breeding population in Florida appears to be increasing rapidly in recent years based upon index nesting data from 1989-2015.

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 also contribute to human caused mortality, though the level is unknown.

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 (Peter 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

The Leatherback sea turtle 5-year review concluded that leatherback nesting has been declining at all major Pacific basin nesting beaches for the last two decades (NMFS and USFWS 2013). In the western Pacific, major nesting beaches occur in Papua, Indonesia; Papua New Guinea; Solomon Islands; and Vanuatu, with an approximate 2,700-4,500 total breeding females, estimated from nest counts (Dutton *et al.* 2007). Papua, Indonesia, have a sizable nesting population with the Jambursba-Medi and Wermon supporting about 75 percent of the regional nesting. However, nest numbers have decreased substantially. Between 1984 and 2011, nesting numbers at the Jambursba-Medi nesting aggregation dropped with 52 percent and the Wermon nesting numbers dropped with 62.8 percent (NMFS and USFWS 2013). Papua New Guinea is estimated to host about 20 percent of regional nesting activity and the Solomon Islands about eight percent (NMFS and USFWS 2013). However, 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. 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.

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 percent, 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 Martínez *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 2007a), indicating that the reductions in nesting females were not as extreme as the reductions predicted by Spotila *et al.* (2000).

On September 26, 2007, we received a petition to revise the critical habitat designation for leatherback sea turtles to include waters along the U.S. West Coast. On December 28, 2007, we published a positive 90-day finding on the petition and convened a critical habitat review team. On January 26, 2012, we published a final rule to revise the critical habitat designation to include three particular areas of marine habitat. The designation includes approximately 16,910 square miles along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour, and 25,004 square miles from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The areas comprise approximately 41,914 square miles of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet. The designated critical habitat areas contain the physical or biological feature essential to the conservation of the species that may require special management conservation or protection. In particular, the team identified one Primary Constituent Element: the occurrence of prey species, primarily scyphomedusae of the order 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 1992b). 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) (Davenport and Balazs 1991, Rebel 1974). However, leatherbacks are also known to use coastal waters of the U.S. continental shelf (Eckert *et al.* 2006, James *et al.* 2005a, 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 percent 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 to 41 percent of their time at the surface, depending on the phase of their migratory cycle (James *et al.* 2005b). The greatest amount of surface time (up to 41%) was recorded when leatherbacks occurred in continental shelf and slope waters north of 38°N (James *et al.* 2005b).

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

Leatherbacks are a long lived species (>30 years). They were originally believed to mature at a younger age than loggerhead sea turtles, with a previous estimated age at sexual maturity of about 13-14 years for females with 9 years reported as a likely minimum (Zug and Parham 1996) and 19 years as a likely maximum (NMFS SEFSC 2001). However, new sophisticated analyses suggest that leatherbacks in the Northwest Atlantic may reach maturity at 24.5-29 years of age (Avens *et al.* 2009). In the United States and Caribbean, female leatherbacks nest from March through July. In the Atlantic, most nesting females average between 150-160 cm curved carapace length (CCL), although smaller (<145 cm CCL) and larger nesters are observed (Stewart *et al.* 2007, TEWG 2007). They nest frequently (up to seven nests per year) during a nesting season and nest about every 2-3 years. They produce 100 eggs or more in each clutch and can produce 700 eggs or more per nesting season (Schulz 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 because 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 most recent five-year review for leatherback sea turtles (NMFS and USFWS 2013) 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 U.S., 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 2013). 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 to 16.3 percent per year, with an overall increase of 10.2 percent 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 exceptions of the Western Caribbean and West Africa groups. 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 a positive population growth rate was found for French Guinea and Suriname using nest numbers from 1967-2005, a 39-year period, and that there was a 95 percent 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 U.S. 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 U.S. at the time of the survey. Estimates of leatherback abundance of 1,052 turtles and 1,174 turtles 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 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 five-year status review (NMFS and USFWS 2013) 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., 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. The most recent section 7 consultation on the shrimp fishery, completed in May 2012, was unable to estimate the total annual level of leatherback interactions occurring in the fishery at present. Instead, it qualitatively estimated that the shrimp fishery, as currently operating, would result in a few hundred interactions annually, of which a subset are expected to be lethal (NMFS 2012).

Leatherbacks have been documented interacting with longline, trap/pot, trawl, and gillnet fishing gear. For instance, an estimated 6,363 leatherback sea turtles were caught by the U.S. Atlantic tuna and swordfish longline fisheries between 1992 and 1999 (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 three-year period starting in 2007 (NMFS 2004). In 2013, there were 72 observed interactions between leatherback sea turtles and longline gear used in the HMS fishery (Garrison and Stokes 2014). All leatherbacks were released alive, with all gear removed in 28 (39%) of the 72 captures. A total of 365.6 (95% CI: 270.2-494.8) leatherback sea turtles are estimated to have interacted with the longline fisheries managed under the HMS FMP in 2013 based on the observed bycatch events (Garrison and Stokes 2014). Compared to historical highs in 2004, the estimated take of leatherbacks has remained low and generally trended downward from 2007-2011, but then sharply increased in 2012 associated with an increase in reported fishing effort. The estimate for 2013 is lower than that for 2012 and is more consistent with estimates during the period from 2004-2011 (Garrison and Stokes 2014). The 2013 estimate remains well below the average prior to implementation of gear regulations (Garrison and Stokes 2014). Since the U.S. fleet accounts for only 5-8 percent 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 (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).

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[2]), 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 on a much smaller scale. In October 2001, for example, a NMFS fisheries observer documented the capture of a leatherback in a bottom otter trawl fishing for *Loligo* squid off Delaware. TEDs are not currently required in this fishery. In November 2007, fisheries observers reported the capture of a leatherback sea turtle in bottom otter trawl gear fishing for summer flounder. Four leatherback sea turtle captures in Mid-Atlantic trawl fisheries were documented by NMFS observers between 2009 and 2013 (Murray 2015).

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 Northeast Fisheries Observer Program (NEFOP) 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 percent. In North Carolina, six additional leatherbacks were reported captured

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

in gillnet sets in the spring (SEFSC 2001). In addition to these, in September 1995, two dead leatherbacks were removed from an 11-inch (28.2-centimeter) monofilament shark gillnet set in the nearshore waters off of Cape Hatteras (STSSN unpublished data reported in SEFSC 2001). Lastly, Murray (2013) reported one observed leatherback capture in Mid-Atlantic sink gillnet fisheries between 2007 and 2011.

Fishing gear interactions can occur throughout the range of leatherbacks, including in Canadian waters. Goff and Lien (1988) reported that 14 of 20 leatherbacks encountered off the coast of Newfoundland/Labrador were entangled in salmon nets, herring nets, gillnets, trawl lines, and crab pot lines. Leatherbacks are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Castroviejo *et al.* 1994, Graff 1990). 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 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 Trinidad and Tobago with mortality estimated to be between 50 percent and 95 percent (Eckert and Lien 1999). Many of the sea turtles do not die as a result of drowning, but rather because the fishermen butcher them to get them out of their nets (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 (Lutcavage *et al.* 1997, Shoop and Kenney 1992). 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 turtle's 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.

Global climate change has been identified as a factor that may affect leatherback habitat and biology (NMFS and USFWS 2013); 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 (Hawkes *et al.* 2007, Mrosovsky *et al.* 1984). 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 (NMFS and USFWS 2013). 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 kilometers in the last few decades as warming has caused the northerly migration of the 15°C 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 2013). Jellyfish populations may increase due to ocean warming and other factors (Attrill *et al.* 2007, Brodeur *et al.* 1999, 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.

As discussed for the other three sea turtle species, increasing temperatures are expected to result in rising sea levels (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 predictable or quantifiable at this time (Hawkes *et al.* 2009). Based on the most recent five-year status review (NMFS and USFWS 2013), and following from the climate change discussion in the previous sections on sea turtles, it is unlikely that impacts from climate change will have a significant effect on the status of leatherbacks over the scope of the action assessed in this Opinion. However, significant impacts from climate change in the future are to be expected, but the severity of and rate at which these impacts will occur is currently unknown.

Summary of Status for Leatherback Sea Turtles

In the Pacific Ocean, the abundance of leatherback sea turtles on nesting beaches has declined dramatically during 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 due to human activities that have reduced the number of nesting females and reduced the reproductive success of females (for example, by egg poaching) (NMFS and USFWS 2013). 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 2013).

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 in this region (NMFS and USFWS 2013). The species as a whole continues to face numerous threats in nesting and marine habitats. As with the other sea turtle species, mortality due to fisheries interactions 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 anthropogenic mortality. The long term recovery potential of this species may be further threatened by observed low genetic diversity, even in the largest nesting groups (NMFS and USFWS 2013).

Based on its five-year status review of the species, NMFS and USFWS (2013) determined that endangered leatherback sea turtles should not be delisted or reclassified. However, it also was 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 2013).

4.6 Shortnose Sturgeon

Shortnose sturgeon are fish that occur in rivers and estuaries along the East Coast of the U.S. and Canada (SSSRT 2010). They have a head covered in bony plates, as well as protective armor called scutes extending from the base of the skull to the caudal peduncle. Other distinctive features include a subterminal, protractile tube-like mouth, and chemosensory barbels for benthic foraging (SSSRT 2010). Sturgeon have been present in North America since the Upper Cretaceous period, more than 66 million years ago. The information below is a summary of available information on the species. Detailed information on the populations that occur in the action area is provided in section 4.7 while details on activities that impact individual shortnose sturgeon in the action area can be found in sections 4.8 and 5.0.

Life History and General Habitat Use

There are differences in life history, behavior and habitat use across the range of the species. Current research indicates that these differences are adaptations to unique features of the rivers where these populations occur. For example, there are differences in larval dispersal patterns in the Connecticut River (MA) and Savannah River (GA) (Parker 2007). There are also morphological and behavioral differences. Growth and maturation occurs more quickly in southern rivers but fish in northern rivers grow larger and live longer.

General life history for the species throughout its range is summarized in the table below:

Table 5: General Life History for the Shortnose Sturgeon (Range-Wide)

Stage	Size (mm)	Duration	Behaviors/Habitat Used
Egg	3-4	13 days post spawn	stationary on bottom; Cobble and rock, fresh, fast flowing water
Yolk Sac Larvae	7-15	8-12 days post hatch	Photonegative; swim up and drift behavior; form aggregations with other YSL; Cobble and rock, stay at bottom near spawning site

Stage	Size (mm)	Duration	Behaviors/Habitat Used
Post Yolk Sac Larvae	15 - 57	12-40 days post hatch	Free swimming; feeding; Silt bottom, deep channel; fresh water
Young of Year	57 – 140 (north); 57-300 (south)	From 40 days post-hatch to one year	Deep, muddy areas upstream of the saltwedge
Juvenile	140 to 450-550 (north); 300 to 450-550 (south)	1 year to maturation	Increasing salinity tolerance with age; same habitat patterns as adults
Adult	450-1100 average; (max recorded1400)	Post-maturation	Freshwater to estuary with some individuals making nearshore coastal migrations

Shortnose sturgeon live on average for 30-40 years (Kynard *et al.* 2016). Males mature at approximately 5-10 years and females mature between age 7 and 13, with later maturation occurring in more northern populations (Kynard *et al.* 2016). Females typically spawn for the first time 5 years post-maturation (age 12-18; age 12-18; age 12-18; age 12-18; age 12-18; age 12-18; age 12-18; age 12-18; Dadswell 1979, Dadswell *et al.* 1984)(age 12-18; Dadswell 1979; Dadswell *et al.* 1984) and then spawn every 3-5 years (Kynard *et al.* 2016). Males spawn for the first time approximately 1-2 years after maturity with spawning typically occurring every 1-2 years (Kynard *et al.* 2016). Shortnose sturgeon are iteroparous (spawning more than once during their life) and females release eggs in multiple “batches” during a 24 to 36-hour period (total of 30,000-200,000 eggs). Multiple males are likely to fertilize the eggs of a single female.

Cues for spawning are thought to include water temperature, day length and river flow (Kynard *et al.* 2016, Kynard *et al.* 2012). Shortnose sturgeon spawn in freshwater reaches of their natal rivers when water temperatures reach 9–15°C in the spring (Kynard *et al.* 2016). Spawning occurs over gravel, rubble, and/or cobble substrate (Kynard *et al.* 2016) in areas with average bottom velocities between 0.4 and 0.8 m/s. Depths at spawning sites are variable, ranging from 1.2 - 27 m (multiple references in SSSRT 2010). Eggs are small and demersal and stick to the rocky substrate where spawning occurs.

Shortnose sturgeon occur in waters between 0 – 34°C (Dadswell *et al.* 1984, Heidt and Gilbert 1978); with temperatures above 28°C considered to be stressful. Depths used are highly variable, ranging from shallow mudflats while foraging to deep channels up to 30 m (Dadswell *et al.* 1984, Kynard 2016). Salinity tolerance increases with age; while young of the year must remain in freshwater, adults have been documented in the ocean with salinities of up 30 parts-per-thousand (ppt) (Kynard *et al.* 2016). Dissolved oxygen affects distribution, with preference for DO levels at or above 5mg/l and adverse effects anticipated for prolonged exposure to DO less than 3.2mg/L (Kynard *et al.* 2016).

Shortnose sturgeon feed on benthic insects, crustaceans, mollusks, and polychaetes (Kynard *et al.* 2016). Both juvenile and adult shortnose sturgeon primarily forage over sandy-mud bottoms, which support benthic invertebrates (Carlson and Simpson 1987, Kynard *et al.* 2016). Shortnose sturgeon have also been observed feeding off plant surfaces (Dadswell *et al.* 1984).

Following spawning, adult shortnose sturgeon disperse quickly down river to summer foraging grounds areas and remain in areas downstream of their spawning grounds throughout the remainder of the year (Kynard *et al.* 2016).

In northern rivers, shortnose aggregate during the winter months in discrete, deep (3-10m) freshwater areas with minimal movement and foraging (Buckley and Kynard 1985, Dadswell 1979, Dovel *et al.* 1992, Kynard *et al.* 2016, Kynard *et al.* 2012). In the winter, adults in southern rivers spend much of their time in the slower moving waters downstream near the salt-wedge and forage widely throughout the estuary (Collins and Smith 1993, Weber *et al.* 1998). Pre-spawning sturgeon in some northern and southern systems migrate into an area in the upper tidal portion of the river in the fall and complete their migration in the spring (Kynard *et al.* 2016). Older juveniles typically occur in the same overwintering areas as adults while young of the year remain in freshwater (Jenkins *et al.* 1993).

Listing History

Shortnose sturgeon were listed as endangered in 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Shortnose sturgeon are thought to have been abundant in nearly every large East Coast river prior to the1880s (Smith and Clugston 1997). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. The species remains listed as endangered throughout its range. While the 1998 Recovery Plan refers to Distinct Population Segments (DPS), the process to designate DPSs for this species has not been undertaken. The SSSRT published a Biological Assessment for shortnose sturgeon in 2010. The report summarized the status of shortnose sturgeon within each river and identified stressors that continue to affect the abundance and stability of these populations.

Current Status

There is no current total population estimate for shortnose sturgeon range wide. Information on populations and metapopulations is presented below. In general, populations in the Northeast are larger and more stable than those in the Southeast (SSSRT 2010). Population size throughout the species' range is considered to be stable; however, most riverine populations are below the historic population sizes and most likely are below the carrying capacity of the river (Kynard 1997, Kynard *et al.* 2016).

Population Structure

There are 19 documented populations of shortnose sturgeon ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Saint John River in New Brunswick, Canada. There is a large gap in the middle of the species range with individuals present in the Chesapeake Bay separated from populations in the Carolinas by a distance of more than 400 km. Currently, there are significantly more shortnose sturgeon in the northern portion of the range.

Recent developments in genetic research as well as differences in life history support the grouping of shortnose sturgeon into five genetically distinct groups, all of which have unique geographic adaptations (see (Grunwald *et al.* 2008, King *et al.* 2001, SSSRT 2010, Waldman *et al.* 2002, Wirgin *et al.* 2005). These groups are: 1) Gulf of Maine; 2) Connecticut and Housatonic Rivers; 3) Hudson River; 4) Delaware River and Chesapeake Bay; and 5) Southeast. The Gulf of Maine, Delaware/Chesapeake Bay and Southeast groups function as metapopulations[3]. The other two groups (Connecticut/Housatonic and the Hudson River) function as independent populations.

While there is migration within each metapopulation (i.e., between rivers in the Gulf of Maine and between rivers in the Southeast) and occasional migration between populations (e.g., Connecticut and Hudson), interbreeding between river populations is limited to very few individuals per generation; this results in morphological and genetic variation between most river populations (Grunwald *et al.* 2008, King *et al.* 2001, SSSRT 2010, Waldman *et al.* 2002, Wirgin *et al.* 2005). Indirect gene flow estimates from mtDNA indicate an effective migration rate of less than two individuals per generation. This means that while individual shortnose sturgeon may move between rivers, very few sturgeon are spawning outside their natal river; it is important to remember that the result of physical movement of individuals is rarely genetic exchange.

Summary of Status of Northeast Rivers

In NMFS's Greater Atlantic Region, shortnose sturgeon are known to spawn in the Kennebec, Androscoggin, Merrimack, Connecticut, Hudson and Delaware Rivers. Shortnose sturgeon are also known to occur in the Penobscot and Potomac Rivers; although it is unclear if spawning is currently occurring in those systems.

Gulf of Maine Metapopulation

Tagging and telemetry studies indicate that shortnose sturgeon are present in the Penobscot, Kennebec, Androscoggin, Sheepscot and Saco Rivers. Individuals have also been documented in smaller coastal rivers; however, the duration of presence has been limited to hours or days and the smaller coastal rivers are thought to be only used occasionally (Zydlewski *et al.* 2011).

Since the removal of the Veazie and Great Works Dams (2013 and 2012, respectively), in the Penobscot River, shortnose sturgeon range from the Bay to the Milford Dam. Shortnose sturgeon now have access to their full historical range. Adult and large juvenile sturgeon have been documented to use the river. While potential spawning sites have been identified, no spawning has been documented. Foraging and overwintering are known to occur in the river. Nearly all pre-spawn females and males have been documented to return to the Kennebec or

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[3] A metapopulation is a group of populations in which distinct populations occupy separate patches of habitat separated by unoccupied areas (Levins 1969). Low rates of connectivity through dispersal, with little to no effective movement, allow individual populations to remain distinct as the rate of migration between local populations is low enough not to have an impact on local dynamics or evolutionary lineages (Hastings and Harrison 1994). This interbreeding between populations, while limited, is consistent, and distinguishes metapopulations from other patchy populations.

Androscoggin Rivers. Robust design analysis with closed periods in the summer and late fall estimated seasonal adult abundance ranging from 636-1285 (weighted mean), with a low estimate of 602 (95%CI: 409.6-910.8) and a high of 1306 (95% CI: 795.6-2176.4) (Fernandes 2008; Fernandes *et al.* 2010; Dionne 2010 in Maine DMR 2010).

Kennebec/Androscoggin/Sheepscot

The estimated size of the adult population (>50cm TL) in this system, based on a tagging and recapture study conducted between 1977-1981, was 7,200 (95% CI = 5,000 - 10,800; Squiers *et al.* 1982). A population study conducted 1998-2000 estimated population size at 9,488 (95% CI = 6,942 -13,358; Squiers 2003)(Squiers 2003) suggesting that the population exhibited significant growth between the late 1970s and late 1990s. Spawning is known to occur in the Androscoggin and Kennebec Rivers. In both rivers, there are hydroelectric facilities located at the base of natural falls thought to be the natural upstream limit of the species. The Sheepscot River is used for foraging during the summer months.

Merrimack River

The historic range in the Merrimack extended to Amoskeag Falls (Manchester, NH, RKM 116; Piotrowski 2002); currently shortnose sturgeon cannot move past the Essex Dam in Lawrence, MA (RKM 46). A current population estimate for the Merrimack River is not available. Based on a study conducted 1987-1991, the adult population was estimated at 32 adults (20–79; 95% confidence interval; B. Kynard and M. Kieffer unpublished information). However, recent gill-net sampling efforts conducted by Kieffer indicate a dramatic increase in the number of adults in the Merrimack River. Sampling conducted in the winter of 2009 resulted in the capture of 170 adults. Preliminary estimates suggest that there may be approximately 2,000 adults using the Merrimack River annually. Spawning, foraging and overwintering all occur in the Merrimack River.

Tagging and tracking studies demonstrate movement of shortnose sturgeon between rivers within the Gulf of Maine, with the longest distance traveled between the Penobscot and Merrimack rivers. Genetic studies indicate that a small, but statistically insignificant amount of genetic exchange likely occurs between the Merrimack River and these rivers in Maine (King *et al.* 2013). The Merrimack River population is genetically distinct from the Kennebec-Androscoggin-Penobscot population (SSSRT 2010). In the Fall of 2014, a shortnose sturgeon tagged in the Connecticut River in 2001 was captured in the Merrimack River. To date, genetic analysis has not been completed and we do not yet know the river of origin of this fish.

Connecticut River Population

The Holyoke Dam divides the Connecticut River shortnose population; there is currently limited successful passage downstream of the Dam. No shortnose sturgeon have passed upstream of the dam since 1999 and passage between 1975-1999 was an average of four fish per year. The number of sturgeon passing downstream of the Dam is unknown. Despite this separation, the populations are not genetically distinct (Kynard 1997, Kynard *et al.* 2016, Wirgin *et al.* 2005). The most recent estimate of the number of shortnose sturgeon upstream of the dam, based on captures and tagging from 1990-2005 is approximately 328 adults (CI = 188–1,264 adults; B.

Kynard, USGS, unpubl. Data in SSSRT 2010); this compares to a previous Peterson mark-recapture estimate of 370–714 adults (Taubert 1980). Using four mark-recapture methodologies, the long-term population estimate (1989-2002) for the lower Connecticut River ranges from 1,042-1,580 (Savoy 2004). Comparing 1989-1994 to 1996-2002, the population exhibits growth on the order of 65-138 percent. The population in the Connecticut River is thought to be stable, but at a small size.

The Turners Falls Dam is thought to represent the natural upstream limit of the species. While limited spawning is thought to occur below the Holyoke Dam, successful spawning has only been documented upstream of the Holyoke Dam. Abundance of pre-spawning adults was estimated each spring between 1994–2001 at a mean of 142.5 spawning adults (CI =14–360 spawning adults) (Kynard *et al.* 2012). Overwintering and foraging occur in both the upper and lower portions of the river. Occasionally, sturgeon have been captured in tributaries to the Connecticut River including the Deerfield River and Westfield River. Additionally, a sturgeon tagged in the CT river was recaptured in the Housatonic River (T. Savoy, CT DEP, pers. comm.). Three individuals tagged in the Hudson were captured in the CT, with one remaining in the river for at least one year (Savoy 2004).

Hudson River Population

The Hudson River population of shortnose sturgeon is the largest in the United States. Studies indicated an extensive increase in abundance from the late 1970s (13,844 adults (Dovel *et al.* 1992), to the late 1990s (56,708 adults (95% CI 50,862 to 64,072; Bain *et al.* 1998). This increase is thought to be the result of high recruitment (31,000 – 52,000 yearlings) from 1986-1992 (Woodland and Secor 2007). Woodland and Secor (2007) examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

Delaware River-Chesapeake Bay Metapopulation

Shortnose sturgeon range from Delaware Bay up to at least Scudders Falls (RKM 223); there are no dams within the species' range on this river. The population is considered stable (comparing 1981-1984 to 1999-2003) at around 12,000 adults (ERC 2006b, Hastings *et al.* 1987). Spawning occurs primarily between Scudders Falls and the Trenton rapids. Overwintering and foraging also occur in the river. Shortnose sturgeon have been documented to use the Chesapeake-Delaware Canal to move from the Chesapeake Bay to the Delaware River.

The current abundance of shortnose sturgeon in the Chesapeake Bay is unknown. Incidental capture of shortnose sturgeon was reported to the USFWS and MDDNR between 1996-2008 as part of an Atlantic Sturgeon Reward Program. During this time, 80 shortnose sturgeon were documented in the Maryland waters of the Bay and in several tidal tributaries. To date, no shortnose sturgeon have been recorded in Virginia waters of the Bay.

Spawning has not been documented in any tributary to the Bay although suitable spawning habitat and two pre-spawning females with late stage eggs have been documented in the Potomac River. Current information indicates that shortnose sturgeon are present year round in the Potomac River with foraging and overwintering taking place there. Shortnose sturgeon captured in the Chesapeake Bay are not genetically distinct from the Delaware River population.

Southeast Metapopulation

There is no evidence of shortnose sturgeon between the mouth of Chesapeake Bay and the Carolinas. Shortnose sturgeon are only thought to occur in the Cape Fear River and Yadkin-Pee Dee River in North Carolina and are thought to be present in very small numbers.

The Altamaha River supports the largest known population in the Southeast with successful self-sustaining recruitment. The most recent population estimate for this river was 6,320 individuals (95% CI = 4,387-9,249; DeVries 2006). The population contains more juveniles than expected. Comparisons to previous population estimates suggest that the population is increasing; however, there is high mortality between the juvenile and adult stages in this river. This mortality is thought to result from incidental capture in the shad fishery, which occurs at the same time as the spawning period (DeVries 2006).

The only available estimate for the Cooper River is of 300 spawning adults at the Pinoplis Dam spawning site (based on 1996-1998 sampling; Cooke *et al.* 2004). This is likely an underestimate of the total number of adults as it would not include non-spawning adults. Estimates for the Ogeechee River were 266 (95% CI=236-300) in 1993 (Weber 1996, Weber *et al.* 1998); a more recent estimate (sampling from 1999-2004; (Fleming *et al.* 2003)) indicates a population size of 147 (95% CI = 104-249). While the more recent estimate is lower, it is not significantly different than the previous estimate. Available information indicates the Ogeechee River population may be experiencing juvenile mortality rates greater than other southeastern rivers.

Spawning is also occurring in the Savannah River, the Congaree River, and the Yadkin-Pee Dee River. There are no population estimates available for these rivers. Occurrence in other southern rivers is limited, with capture in most other rivers limited to fewer than five individuals. They are thought to be extremely rare or possibly extirpated from the St. Johns River in Florida as only a single specimen was found by the Florida Fish and Wildlife Conservation Commission during extensive sampling of the river in 2002/2003. In these river systems, shortnose sturgeon occur in nearshore marine, estuarine, and riverine habitat.

Threats

Because sturgeon are long-lived and slow growing, stock productivity is relatively low; this can make the species vulnerable to rapid decline and slow recovery (Musick 1999). In well studied rivers (e.g., Hudson, upper Connecticut), researchers have documented significant year to year recruitment variability (up to 10 fold over 20 years in the Hudson and years with no recruitment in the CT). However, this pattern is not unexpected given the life history characteristics of the species and natural variability in hydrogeologic cues relied on for spawning.

The small amount of effective movement between populations means recolonization of currently extirpated river populations is expected to be very slow and any future recolonization of any rivers that experience significant losses of individuals would also be expected to be very slow. Despite the significant decline in population sizes over the last century, gene diversity in shortnose sturgeon is moderately high in both mtDNA (Quattro *et al.* 2002, Wirgin *et al.* 2005) and nDNA (King *et al.* 2001) genomes.

A population of sturgeon can go extinct as a consequence of demographic stochasticity (fluctuations in population size due to random demographic events); the smaller the metapopulation (or population); the more prone it is to extinction. Anthropogenic impacts acting on top of demographic stochasticity further increase the risk of extinction.

All shortnose sturgeon populations are highly sensitive to increases in juvenile mortality that would result in chronic reductions in the number of sub-adults as this leads to reductions in the number of adult spawners (Gross *et al.* 2002, Secor 2002). Populations of shortnose sturgeon that do not have reliable natural recruitment are at increased risk of experiencing population decline leading to extinction (Secor *et al.* 2002). Elasticity studies of shortnose sturgeon indicate that the highest potential for increased population size and stability comes from YOY and juveniles as compared to adults (Gross *et al.* 2002); that is, increasing the number of YOY and juveniles has a more significant long term impact to the population than does increasing the number of adults or the fecundity of adults.

The Shortnose Sturgeon Recovery Plan (NMFS 1998) and the Shortnose Sturgeon Status Review Team's Biological Assessment of shortnose sturgeon (2010) identify habitat degradation or loss and direct mortality as principal threats to the species' survival. Natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon and include: poaching, bycatch in riverine fisheries, habitat alteration resulting from the presence of dams, in-water and shoreline construction, including dredging; degraded water quality which can impact habitat suitability and result in physiological effects to individuals including impacts on reproductive success; direct mortality resulting from dredging as well as impingement and entrainment at water intakes; and, loss of historical range due to the presence of dams. Shortnose sturgeon are also occasionally killed as a result of research activities. The total number of sturgeon affected by these various threats is not known. Climate change, particularly shifts in seasonal temperature regimes and changes in the location of the salt wedge, may impact shortnose sturgeon in the future (more information on Climate Change is presented in Section 7.0). More information on threats experienced in the action area is presented in the Environmental Baseline section of this Opinion.

Survival and Recovery

The 1998 Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely; the minimum population size for each population has not yet been determined.

The Recovery Outline contains three major tasks: (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. In many rivers, particularly in the Southeast, habitat is compromised and continues to impact the ability of sturgeon populations to recover. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. The loss of any population or metapopulation would result in the loss of biodiversity and would create (or widen) a gap in the species' range.

Summary of Status

Shortnose sturgeon remain listed as endangered throughout their range, with populations in the Northeast being larger and generally more stable than populations in the Southeast. All populations are affected by mortality incidental to other activities, including dredging, power plant intakes and shad fisheries where those still occur, and impacts to habitat and water quality that affect the ability of sturgeon to use habitats and impacts individuals that are present in those habitats. While the species is overall considered to be stable (i.e., its trend has not changed recently, and we are not aware of any new or emerging threats that would change the trend in the future), we lack information on abundance and population dynamics in many rivers. We also do not fully understand the extent of coastal movements and the importance of habitat in non-natal rivers to migrant fish. While the species has high levels of genetic diversity, the lack of effective movement between populations increases the vulnerability of the species should there be a significant reduction in the number of individuals in any one population or metapopulation as recolonization is expected to be very slow. All populations, regardless of size, are faced with threats that result in the mortality of individuals and/or affect the suitability of habitat and may restrict the further growth of the population. Additionally, there are several factors that combine to make the species particularly sensitive to existing and future threats; these factors include: the small size of many populations, existing gaps in the range, late maturation, the sensitivity of adults to very specific spawning cues which can result in years with no recruitment, and the impact of losses of young of the year and juveniles to population persistence and stability.

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.). We have delineated U.S. populations of Atlantic sturgeon into five DPSs (77 FR 5880 and 77 FR 5914, February 6, 2012). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 6). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

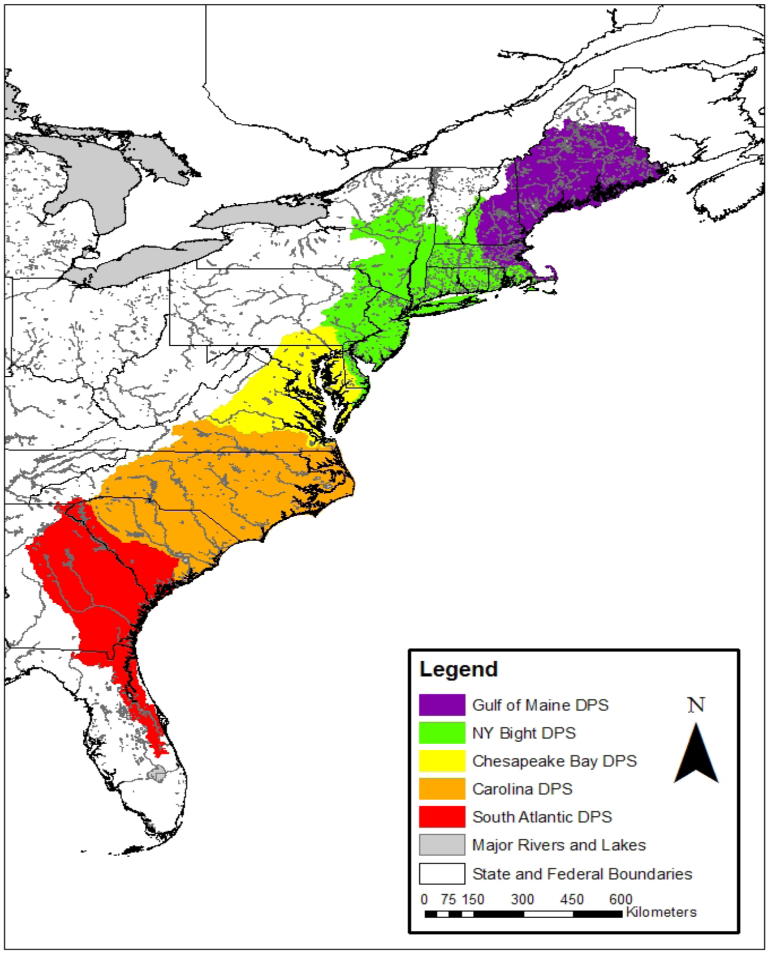

Figure 7: Map Depicting the five Atlantic sturgeon DPSs

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

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

4.7.1 Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Delaware River and estuary. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Delaware River, and thereby, in the action area, will have originated from the Delaware River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Delaware River and estuary would not be limited to just individuals originating from the NYB DPS. Based on mixed-stock analysis, we have determined that subadult and adult Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: Gulf of Maine 7 percent; NYB 58 percent; Chesapeake Bay 18 percent; South Atlantic 17 percent; and Carolina 0.5 percent. 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 (described in detail in described in detail in described in detail in described in detail in Damon-Randall *et al.* 2013). This is the closest sampling effort (geographically) to the action area for which mixed stock analysis results are available. Because the genetic composition of the mixed stock changes with distance from the rivers of origin, it is appropriate to use mixed stock analysis results from the nearest sampling location. Therefore, this represents the best available information on the likely genetic makeup of individuals occurring in the action area.

We also considered information on the genetic makeup of subadults and adults captured within the Delaware River. However, we only have information on the assignment of these individuals to the river of origin and do not have a mixed stock analysis for these samples. The river assignments are very similar to the mixed stock analysis results for the Delaware Coastal sampling, with the Hudson/Delaware accounting for 55-61 percent of the fish, James River accounting for 17-18 percent, Savannah/Ogeechee/Altamaha 17-18 percent, and Kennebec 9-11 percent. 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 percent of the fish sampled were Carolina DPS origin. Additionally, 4 percent of Atlantic sturgeon captured incidentally in commercial fisheries along the U.S. Atlantic coast north of Cape Hatteras, and genetically analyzed, belong to the Carolina DPS. Because any Carolina origin sturgeon that were sampled in Long Island Sound could have swam through the action area on their way between Long Island Sound and their rivers of origin, it is reasonable to expect that 0.5 percent of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. The genetic assignments have a plus/minus 5 percent 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.* (2013).

4.7.2 Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[4] fish (ASSRT 2007, Hilton *et al.* 2016). The life history of Atlantic sturgeon can be divided up into five general categories as described in the table below (adapted from ASSRT 2007).

Table 6: Descriptions of Atlantic sturgeon life history stages

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

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[4] 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)

Atlantic sturgeons are bottom feeders that grabs 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 (ASSRT 2007, Hilton *et al.* 2016). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (ASSRT 2007, Hilton *et al.* 2016).

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (ASSRT 2007, Hilton *et al.* 2016, Kahnle *et al.* 2007). 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 (ASSRT 2007, Dovel 1979, Hilton *et al.* 2016, Van Eenennaam and Doroshov 1998, Van Eenennaam *et al.* 1996). 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 (Dadswell 2006, Hilton *et al.* 2016, Van Eenennaam and Doroshov 1998, Van Eenennaam *et al.* 1996, Vladykov and Greeley 1963). 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 (Hilton *et al.* 2016). 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 (Hilton *et al.* 2016). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (ASMFC 2009, ASSRT 2007, Hilton *et al.* 2016), and remain on the spawning grounds throughout the spawning season (Bain 1997, Hilton *et al.* 2016). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Hilton *et al.* 2016), make rapid spawning migrations upstream, and quickly depart following spawning (Hilton *et al.* 2016).

While the exact spawning locations in all rivers are not known, 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 (ASMFC 2009, Hilton *et al.* 2016, Kahnle *et al.* 2007). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Hilton *et al.* 2016), and become adhesive shortly after fertilization (Hilton *et al.* 2016). 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 (Smith 1985, Smith *et al.* 1980).

Yolk sac larvae (also called free embryos) are photonegative, do not disperse, live of the yolk in their yolk sac (i.e. endogenous feeding), and seek refuge in coarse substrate (Kynard and Horgan 2002). The yolk is absorbed within 6 tp 12 days. At this stage, the larvae emerge from the substrate, are photpositive, initiate exogenous feeding, and display drifting behavior (swim up and drift) (Kynard and Horgan 2002). Sturgeon early life stages are intolerant of saline water and drifting must stop before entering the saltwater front. Thus, drifting is expected to bring the larvae to nursery areas above the salt front of the tidal river where one would expect the larvae to settle out of the water column and begin foraging (Hilton *et al.* 2016). Hudson River larvae displayed drifting in an artificial stream for up to 12 days after which they started to hold against the current and became demersal (Kynard and Horgan 2002).

Few studies have looked at the behavior, habitat use, or channel distribution of Atlantic sturgeon post yolk sac larvae once they settle. Thus, little is known about their habitat use or distribution within the river channel. They do have an association with fine sediment and may be, at least partly, visual predators preying on copepods and insect larvae (Hilton *et al.* 2016, Kynard and Horgan 2002). Their small size, incomplete development of the fins, and lack of a fully developed swim bladder limits their swimming performance. Based on the above, non-drifting larvae may seek lower current velocities, less turbid waters, silt substrate, and areas with insect larvae and zooplankton. The larvae develop a full complement of fin rays and develop into the juvenile stage after about 60 days post-hatch and at a size of about 58 mm (Hilton *et al.* 2016).

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 (Hatin *et al.* 2007b, 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 (Hilton *et al.* 2016).

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 40 m in depth, using coastal bays, sounds, and ocean waters (Breece *et al.* 2016, Breece *et al.* 2017, Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Savoy and Pacileo 2003, Stein *et al.* 2004a, b, Vladykov and Greeley 1963). 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 subadult Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, subadult 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 (Breece *et al.* 2016, Breece *et al.* In press, Dovel and Berggren 1983a, Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Stein *et al.* 2004a, b). These sites may be used as foraging sites and/or thermal refuge.

4.7.3 Distribution and Abundance

In the mid to late 19th century, Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing for the caviar market (ASSRT 2007, Dadswell 2006, Smith and Clugston 1997, Taub 1990). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware River, and at least 10,000 females for other spawning stocks (Secor 2002, Secor and Waldman 1999). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 17 U.S. rivers are known to support spawning (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only five rivers (Kennebec, Androscoggin, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia, where historical records show that there used to be 15 spawning rivers (ASSRT 2007). Currently, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could slow the rate of recolonization of extirpated populations.

At the time of the listing, there were no current, published population abundance estimates for any of the currently known spawning stocks or for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985 to 1995 (Kahnle *et al.* 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson 2010). Using the data collected from the Hudson and Altamaha Rivers to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Hilton *et al.* 2016), the age structure of these populations is not well understood, and stage-to-stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (e.g., yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT 2007).

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NEFSC developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (see see see see Kocik *et al.* 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (see Table 7 and Table 8). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the United States Fish and Wildlife Service (USFWS) sturgeon tagging database[5], and federal fishery discard estimates from 2006 to 2010 to produce a virtual population.

In additional to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 7 and Table 8). NEAMAP trawl surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall and spring. Fall surveys have been ongoing since 2007 and spring surveys since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

Table 7: Description of the ASPI model and NEAMAP survey based area estimate method

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

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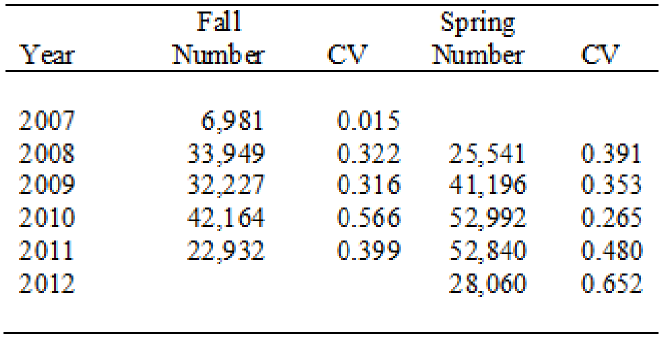
[5] The USFWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag, release, and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery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

Table 8: Modeled Results

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

The information from the NEAMAP survey can be used to calculate minimum swept area population estimates within the strata swept by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 9). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e. net efficiency) 100 percent of the sturgeon in the water column along the tow path and that all sturgeon are with the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100 percent will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100 percent are common for most species. The ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, but is certainly greater than one (i.e. the NEAMAP survey does not survey 100 percent of the Atlantic sturgeon habitat).

Table 9: Annual minimum swept area estimates for Atlantic sturgeon during the spring and fall from the Northeast Area Monitoring and Assessment Program survey. Estimates assume 100 percent net efficiencies. Estimates provided by Dr. Chris Bonzek (VIMS)



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

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

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

The ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey (see Table 8). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the U. S. Fish and Wildlife Service (USFWS) sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The NEAMAP estimate, in contrast, does not depend on as many assumptions. For the purposes of this Opinion, we consider the NEAMAP estimate resulting from the 50 percent catchability rate, as the best available information on the number of subadult and adult Atlantic sturgeon in the ocean.

The ocean population abundance of 67,776 fish estimated from the NEAMAP survey assuming 50 percent efficiency (based on net efficiency and the fraction of the total population exposed to the survey) was subsequently partitioned by DPS based on genetic frequencies of occurrence (Table 10) in the sampled area. Given the proportion of adults to subadults in the observer database (approximate ratio of 1:3), we have also estimated a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults.

Table 10: Summary of calculated population estimates based upon the NEAMAP Survey swept area*

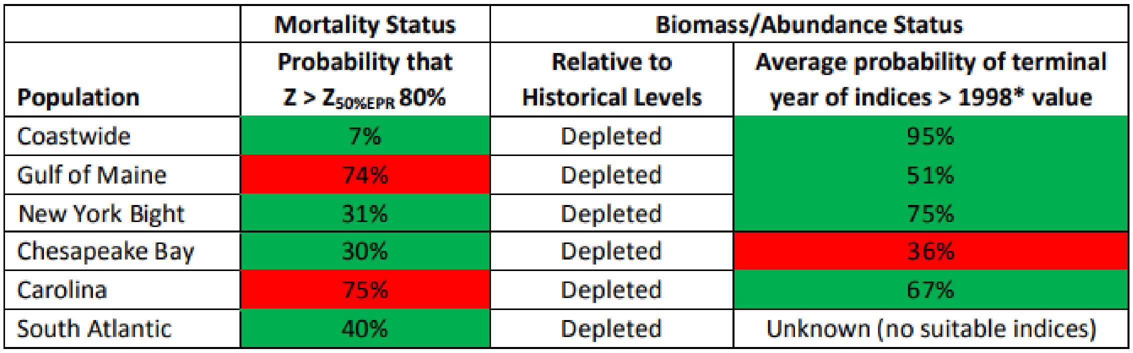
DPS	Estimated Ocean Population Abundance	Estimated Ocean Population of Adults	Estimated Ocean Population of Subadults (of size vulnerable to capture in fisheries)
GOM	7,455	1,864	5,591
NYB**	34,566	8,642	25,925
CB	8,811	2,203	6,608
Carolina	1,356	339	1,017
SA	14,911	3,728	11,183
Canada	678	170	509

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

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

The ASMFC released a new Atlantic sturgeon stock assessment in October 2017. The assessment used both fishery dependent and fishery independent data, as well as biological and life history information. Fishery-dependent data came from commercial fisheries that formerly targeted Atlantic sturgeon (before the moratorium), as well as fisheries that catch sturgeon incidentally. Fishery-independent data were collected from scientific research and survey programs.

Table 11: Stock status determination for the coastwide stock and DPSs (from ASMFC's Atlantic Sturgeon Stock Assessment Overview, October 2017)



	Mortality Status	**Biomass/Abundance Status**	
Population	**Probability that $Z > Z_{50\%EPR}$ 80%**	**Relative to Historical Levels**	**Average probability of terminal year of indices > 1998* value**
Coastwide	7%	Depleted	95%
Gulf of Maine	74%	Depleted	51%
New York Bight	31%	Depleted	75%
Chesapeake Bay	30%	Depleted	36%
Carolina	75%	Depleted	67%
South Atlantic	40%	Depleted	Unknown (no suitable indices)

*For indices that started after 1998, the first year of the index was used as the reference value.

At the coastwide and DPS levels, the stock assessment concluded that Atlantic sturgeon are depleted relative to historical levels. The low abundance of Atlantic sturgeon is not due solely to effects of historic commercial fishing, so the 'depleted' status was used instead of 'overfished.' This status reflects the array of variables preventing Atlantic sturgeon recovery (e.g., bycatch, habitat loss, and ship strikes).

As described in the Assessment Overview, Table 11 shows "the stock status determination for the coastwide stock and DPSs based on mortality estimates and biomass/abundance status relative to historic levels, and the terminal year (i.e., the last year of available data) of indices relative to the start of the moratorium as determined by the ARIMA[6] analysis."

Despite the depleted status, the assessment did include signs that the coastwide index is above the 1998 value (95% chance). The Gulf of Maine DPS, New York Bight DPS, and Carolina DPS indices also all had a greater than 50 percent chance of being above their 1998 value; however, the index from the Chesapeake Bay DPS (highlighted red) only had a 36 percent chance of being above the 1998 value. There were no representative indices for the South Atlantic DPS. Total mortality from the tagging model was very low at the coastwide level. Small sample sizes made mortality estimates at the DPS level more difficult. The New York Bight, Chesapeake Bay, and South Atlantic DPSs all had a less than 50 percent chance of having a mortality rate higher than the threshold. The Gulf of Maine and Carolina DPSs (highlighted red) had 74-75 percent probability of being above the mortality threshold (ASMFC 2017).

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 (Pikitch *et al.* 2005, Vladykov and Greeley 1963), 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 (Secor and Waldman 1999, Smith and Clugston 1997, Taub 1990).

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

Based on the best available information, we have concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of

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[6] "The ARIMA (Auto-Regressive Integrated Moving Average) model uses fishery-independent indices of abundance to estimate how likely an index value is above or below a reference value" (ASMFC 2017).

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 2011, Wirgin and King 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian directed Atlantic sturgeon fisheries and of Canadian fish incidentally in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

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

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

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

Based on the results of NOAA Fisheries NEFSC's climate vulnerability analysis, diadromous fish are amongst the functional groups with the highest overall climate vulnerability (data quality is moderate; data quality is moderate; data quality is moderate; data quality is moderate; Hare *et al.* 2016b). Specifically, the overall vulnerability of Atlantic sturgeon to climate change is very high (Hare *et al.* 2016b). The contributing factors to climate exposure included ocean surface temperature, air temperature and ocean acidification, and contributing biological sensitivity attributes included stock status, population growth rate, habitat specialization, and dispersal and early life history (Hare *et al.* 2016b). Hare et al (2016a) noted some of the following studies related to climate change effects on abundance and distribution: 1) juvenile metabolism and survival were impacted by increasing hypoxia in combination with increasing temperature (Secor and Gunderson 1998); and 2) a 1ºC temperature increase reduced productivity by 65 percent when a multivariable bioenergetics and survival model was used to generate spatially explicit maps of potential production in the Chesapeake Bay (Niklitschek and Secor 2005).

4.8 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT 2007). Spawning still occurs in the Kennebec River, and it is possible that it still occurs in the Penobscot River as well. 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 (ASSRT 2007). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Kieffer 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 (Hilton *et al.* 2016). 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 (ASMFC 2007, Hilton *et al.* 2016). 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 (Squires *et al.* 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squires *et al.* 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by-catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still 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 (ASMFC 2007, Stein *et al.* 2004a). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

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

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at a dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam and the Great Works Dam, sturgeon can now travel as far upstream as the Milford Dam. While Atlantic sturgeon are known to occur in the Penobscot River, there is no evidence of spawning currently occurring. The Essex Dam on the Merrimack River blocks access to approximately 58 percent 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). Many rivers in Maine, including the Androscoggin River, were heavily polluted in the past from industrial discharges from pulp and paper mills. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

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

Summary of the Gulf of Maine DPS

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

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8 percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.* 2012).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (ASMFC 2007, Boreman 1997, Brown and Murphy 2010, Kahnle *et al.* 2007). 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 (ASSRT 2007, Hilton *et al.* 2016, Murawski and Pacheco 1977, Secor 2002). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence of spawning in the Taunton Rivers (ASSRT, 2007); several age-0 Atlantic sturgeon were captured in the Connecticut in June 2014, suggesting that occasional successful spawning may occur in the Connecticut River (Savoy *et al.* 2017). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (Hilton *et al.* 2016, Savoy 2007, Savoy and Pacileo 2003).

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 (ASSRT 2007, Kahnle *et al.* 2007, Secor 2002). 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.* (2007), Kahnle *et al.* (1998) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. A decline in the abundance of young Atlantic sturgeon appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (ASMFC 2017, Kahnle *et al.* 1998, Sweka 2006). At the time of listing, catch-per-unit-effort (CPUE) data suggested that recruitment remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980's (ASMFC 2017, Kahnle *et al.* 1998, Sweka 2006). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s while the CPUE is generally higher in the 2000s as compared to the 1990s. Given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. Standardized mean catch per net set from the NYSDEC juvenile Atlantic sturgeon survey have had a general increasing trend from 2006 – 2015, with the exception of a dip in 2013.

In addition to capture in fisheries operating in Federal waters, bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (shad) in the Hudson River, has now been closed and there is no indication that it will reopen soon. In the Hudson River sources of potential mortality include vessel strikes and entrainment in dredges. Individuals are also exposed to effects of bridge construction (including the ongoing replacement of the Tappan Zee bridge). Impingement at water intakes, including the Danskammer, Roseton and Indian Point power plants also occurs. Recent information from surveys of juveniles (see above) indicates that the number of young Atlantic sturgeon in the Hudson River is increasing compared to recent years, but is still low compared to the 1970s. There is currently not enough information regarding any life stage to establish a trend for the entire Hudson River population.

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800s indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor 2002, Secor and Waldman 1999). 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 2011) and the collection of 32 YOY Atlantic sturgeon in a separate study (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 1998, 2007). 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 (ASMFC 2007, Stein *et al.* 2004a). As explained above, currently available estimates indicate that at least 4 percent 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 percent 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 total number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects. We are also not able to quantify any cumulative effects to habitat. In Table 15, we provide all data for documented sturgeon takes in hopper dredging operations within the Action Area for this project.

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

New York Bight DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Hudson and Delaware over the past decades (Lichter *et al.* 2006). 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 (Brown and Murphy 2010). Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Additionally, 138 sturgeon carcasses were observed on the Hudson River and reported to the NYSDEC between 2007 and 2015. Of these, 69 are suspected of having been killed by vessel strike. Genetic analysis has not been completed on any of these individuals to date, given that the majority of Atlantic sturgeon in the Hudson River belong to the New York Bight DPS, we assume that the majority of the dead sturgeon reported to NYSDEC belonged to the New York Bight DPS. Given the time of year in which the fish were observed (predominantly May through July), it is likely that many of the adults were migrating through the river to the spawning grounds.

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

4.10 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). It is believed that 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 (ASMFC 2007, Greene *et al.* 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 (ASSRT 2007, Grunwald *et al.* 2008, Vladykov and Greeley 1963, Wirgin *et al.* 2007).

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 (ASMFC 1998a, ASSRT 2007, Vladykov and Greeley 1963) as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century (ASSRT 2007, Balazik *et al.* 2010, Bushnoe *et al.* 2005, Secor 2002). 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 (ASSRT 2007, Bushnoe *et al.* 2005). 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 (ASMFC 1998b, ASSRT 2007, Bushnoe *et al.* 2005, Pyzik *et al.* 2004). 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, Balazik *et al.* 2012b). 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 Chesapeake Bay DPS.

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

Summary of the Chesapeake Bay DPS

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

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

4.11 Carolina DPS of Atlantic sturgeon

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

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

Threats

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

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

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

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

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

Additional data regarding sturgeon use of riverine and estuarine environments is needed.

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

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

Summary of the Status of the Carolina DPS of Atlantic Sturgeon

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

The presence of dams has resulted in the loss of over 60 percent of the historical sturgeon habitat on the Cape Fear River and in the Santee-Cooper system. Dams are contributing to the endangered status of the Carolina DPS by curtailing the extent of available spawning habitat and further modifying the remaining habitat downstream by affecting water quality parameters (such as depth, temperature, velocity, and DO) that are important to sturgeon. Dredging is also contributing to the status of the Carolina DPS by modifying Atlantic sturgeon spawning and nursery habitat. Habitat modifications through reductions in water quality are contributing to the status of the Carolina DPS due to nutrient-loading, seasonal anoxia, and contaminated sediments. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch is also a current threat to the Carolina DPS that is contributing to its status. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may utilize multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning. While many of the threats to the Carolina DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch is currently not being addressed through existing mechanisms. Further, access to habitat and water quality continues to be a problem even with NMFS' authority under the Federal Power Act to recommend fish passage and existing controls on some pollution sources. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the Carolina DPS.

4.12 South Atlantic DPS of Atlantic sturgeon

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

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, Satilla Rivers, and St. Marys. We determined spawning was occurring if young-of-the-year (YOY) were observed, or mature adults were present, in freshwater portions of a system. 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, the Broad-Coosawatchie was documented to have spawning populations; there is also evidence that spawning may have occurred in the St. Johns River or one of its tributaries. However, the 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. The St. Johns Rivers is 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.
Secor (2002) estimates that 8,000 adult females were present in South Carolina prior to 1890. Prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery in Georgia. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in the state prior to 1890. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the South Atlantic DPS. Currently, the Atlantic sturgeon spawning population in at least two river systems within the South Atlantic DPS has been extirpated. The Altamaha River population of Atlantic sturgeon, with an estimated 343 adults spawning annually, is believed to be the largest population in the Southeast, yet is estimated to be only 6 percent of its historical population size. The ASSRT estimated the abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, to be less than 1 percent of what they were historically (ASSRT 2007).

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

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

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

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

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

A viable population able to adapt to changing environmental conditions is critical to Atlantic sturgeon, and the low population numbers of every river population in the South Atlantic DPS put them in danger of extinction throughout their range. None of the populations are large or stable enough to provide with any level of certainty for continued existence of Atlantic sturgeon in this part of its range. Although the largest impact that caused the precipitous decline of the species has been curtailed (directed fishing), the population sizes within the South Atlantic DPS have remained relatively constant at greatly reduced levels for 100 years. Small numbers of individuals resulting from drastic reductions in populations, such as occurred with Atlantic sturgeon due to the commercial fishery, can remove the buffer against natural demographic and environmental variability provided by large populations (Berry 1971, Jamieson and Allendorf 2012, Shaffer 1981). Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon, and they continue to face a variety of other threats that contribute to their risk of extinction. While a long life-span also allows multiple opportunities to contribute to future generations, it also increases the timeframe over which exposure to the multitude of threats facing the South Atlantic DPS can occur.

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

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

Dredging is contributing to the status of the South Atlantic DPS by modifying spawning, nursery, and foraging habitat. Habitat modifications through reductions in water quality are also contributing to the status of the South Atlantic DPS through reductions in DO, particularly during times of high water temperatures, which increase the detrimental effects on Atlantic sturgeon habitat. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch is also a current impact to the South Atlantic DPS that is contributing to its status. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may utilize multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning. While many of the threats to the South Atlantic DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch is currently not being addressed through existing mechanisms. Further, access to habitat and water quality continues to be a problem even with NMFS' authority under the Federal Power Act to recommend fish passage and existing controls on some pollution sources. There is a lack of regulation for some large water withdrawals, which threatens sturgeon habitat. Current regulatory regimes do not require a permit for water withdrawals under 100,000 gpd in Georgia and there are no restrictions on interbasin water transfers in South Carolina. Existing water allocation issues will likely be compounded by population growth, drought, and potentially climate change. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the South Atlantic DPS.

4.13 Critical Habitat Designated for the New York Bight DPS of Atlantic Sturgeon

On August 17, 2017, we issued a final rule to designate critical habitat for the threatened Gulf of Maine DPS of Atlantic sturgeon, the endangered New York Bight DPS of Atlantic sturgeon, the endangered Chesapeake Bay DPS of Atlantic sturgeon, the endangered Carolina DPS of Atlantic sturgeon, and the endangered South Atlantic DPS of Atlantic sturgeon (82 FR 39160).
The rule was effective on September 18, 2017. The action area overlaps with the the Delaware River critical habitat unit designated for the New York Bight DPS.

The conservation objective identified in the final rule is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment. We designated four critical habitat units to achieve this objective for the New York Bight DPS: (1) Connecticut River from the Holyoke Dam downstream for 140 RKMs to where the main stem river discharges at its mouth into Long Island Sound; (2) Housatonic River from the Derby Dam downstream for 24 RKMs to where the main stem discharges at its mouth into Long Island Sound; (3) Hudson River from the Troy Lock and Dam (also known as the Federal Dam) downstream for 246 RKMs to where the main stem river discharges at its mouth into New York City Harbor; and, (4) Delaware River at the crossing of the Trenton-Morrisville Route 1 Toll Bridge, downstream for 137 RKMs to where the main stem river discharges at its mouth into Delaware Bay. In total, these designations encompass approximately 547 kilometers (340 miles) of aquatic habitat.

As identified in the final rule, the physical features that are essential to the conservation of the species and that may require special management considerations or protection are:

1) Hard bottom substrate (*e.g.*, rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.*, 0.0 to 0.5 parts per thousand (ppt) range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
2) Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.*, sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;

3) Water of appropriate depth and absent physical barriers to passage (*e.g.*, locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:
    (i) Unimpeded movement of adults to and from spawning sites;
    (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and
    (iii) Staging, resting, or holding of subadults or spawning condition adults.

    Water depths in main river channels must also be deep enough (*e.g.,* at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.

4) Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support:
    (i) Spawning;
    (ii) Annual and interannual adult, subadult, larval, and juvenile survival; and
    (iii) Larval, juvenile, and subadult growth, development, and recruitment (*e.g.*,13 °C to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) dissolved oxygen (DO) or greater for juvenile rearing habitat).

The paragraphs that follow are excerpted from the ESA Section 4(b)(2) Report for Atlantic sturgeon critical habitat (NMFS 2017). That document provides background information on the current status and function of the four critical habitat units designated for the New York Bight DPS, and summarizes their ability to support reproduction, survival, and juvenile development, and recruitment. Additional information on the status of the New York Bight DPS relevant to the current status and function of critical habitat can be found in Section 4.9.

> At the time of listing, the Delaware and Hudson rivers were the only rivers where spawning was known to still occur for the New York Bight DPS of Atlantic sturgeon (ASSRT 2007, Bain 1997, Calvo *et al.* 2010, Dovel and Berggren 1983b, Kahnle *et al.* 2007). In 2014, several small Atlantic sturgeon were captured in the Connecticut River (T. Savoy, CT DEEP, pers. comm.; T. Savoy, CT DEEP, pers. comm.; T. Savoy, CT DEEP, pers. comm.; T. Savoy, CT DEEP, pers. comm.; Savoy *et al.* 2017). Though it was previously thought that the Atlantic sturgeon population in the Connecticut had been extirpated (ASSRT 2007, Savoy and Pacileo 2003), Analysis of tissues collected from the captured sturgeon indicate the Connecticut River sturgeon are genetically different than sturgeon that are spawned in the Delaware and Hudson rivers (Savoy *et al.* 2017), and strongly suggests that the Connecticut River supports an Atlantic sturgeon spawning population.
>
> The Connecticut River has long been known as a seasonal aggregation area for subadult Atlantic sturgeon, and both historical and contemporary records document presence of

Atlantic sturgeon in the river as far upstream as the Holyoke Dam in Hadley, MA (Savoy and Shake, 1993; Savoy and Pacileo, 2003; ASSRT, 2007). The Enfield Dam located along the fall line at Enfield, CT prevented upstream passage of Atlantic sturgeon from 1827 until it was breached in 1977 (ASSRT 2007). The maximum upriver extent of the salt front is to RKM 26. In the spring, high freshwater flow can push the salt front downriver, beyond the river mouth, into Long Island Sound. Tidal influence extends upriver to RKM 90.

In August 2006, an adult-sized Atlantic sturgeon was observed as far upriver as the Holyoke Dam spillway lift at approximately RKM 143 (ASSRT, 2007). However, Atlantic sturgeon are more commonly known to occur further downstream of the Holyoke Dam (Savoy 2007). As noted previously, capture of juvenile (based on size) Atlantic sturgeon in the Connecticut River in 2014, and genetic analysis of tissues collected from the sturgeon strongly suggests spawning is occurring in the river (Savoy *et al.* 2017).

The Hudson River is one of the most studied areas for Atlantic sturgeon. The upstream limit for Atlantic sturgeon on the Hudson River is the Federal Dam at the fall line in Troy, NY, approximately RKM 246 (ASSRT 1998, Dovel and Berggren 1983a, Hilton *et al.* 2016). Recent tracking data indicate Atlantic sturgeon presence at this upstream limit (D. Fox, DESU, pers. comm.). Sturgeon occurring in the upstream limits of the river are suspected, but not yet confirmed, to belong to the New York Bight DPS. Spawning may occur in multiple sites within the river (Bain *et al.* 2000, Dovel and Berggren 1983a, Hilton *et al.* 2016, Kahnle *et al.* 1998, Van Eenennaam *et al.* 1996). The area around Hyde Park (approximately RKM 134) is considered a likely spawning area based on scientific studies and historical records of the Hudson River sturgeon fishery (Bain *et al.* 2000, Dovel and Berggren 1983a, Kahnle *et al.* 1998, Van Eenennaam *et al.* 1996). Habitat conditions at the Hyde Park site are described as freshwater year round with substrate including bedrock, and water depths of 12 to 24 meters (Bain *et al.* 2000). Similar conditions occur at RKM 112, an area of freshwater and water depths of 21 to 27 meters (Bain *et al.* 2000).

Catches of Atlantic sturgeon less than 63 centimeter fork length suggest that sexually immature fish utilize the Hudson River estuary from the Tappan Zee (RKM 40) through Kingston (RKM 148) (Bain *et al.* 2000, Dovel and Berggren 1983a, Hilton *et al.* 2016). Seasonal movements of the immature fish are apparent as they primarily occupy waters from RKM 60 to RKM 107 during summer months and then move downstream as water temperatures decline in the fall, primarily occupying waters from RKM 19 to RKM 74 (Bain *et al.* 2000, Dovel and Berggren 1983b, Haley 1999). In a separate study, Atlantic sturgeon ranging in size from 32 to 101 cm fork length were captured at highest concentrations during spring in soft-deep areas of Haverstraw Bay even though this habitat type comprised only 25 percent of the available habitat in the Bay (Sweka 2006).

In the Delaware River, there is evidence of Atlantic sturgeon presence from the mouth of the Delaware Bay to the head of tide at the fall line near Trenton, New Jersey and Morrisville, Pennsylvania, a distance of 220 RKMs (Breece *et al.* 2013, Brundage and O'Herron 2009, Calvo *et al.* 2010, Fisher 2011, Shirey *et al.* 1997, Simpson 2008). There are no dams on the Delaware River and an Atlantic sturgeon carcass was found as far upstream as Easton, PA in 2014 (M. Fisher, DE DNREC, pers. comm.) suggesting that sturgeon can move beyond the fall line.

Hard bottom habitat believed to be appropriate for sturgeon spawning (gravel/coarse grain depositional material and cobble/boulder habitat) occurs between the Marcus Hook Bar (RKM 134) and the mouth of the Schuylkill River (RKM 148) (Sommerfield and Madsen 2003). Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat exists from Tinicum Island (RKM 136) to the fall line in Trenton, NJ (RKM 211). Tracking of 10 male and 2 female sturgeon belonging to the New York Bight DPS and presumed to be adults based on their size (> 150 cm fork length) indicated that each of the 12 sturgeon spent 7 to 70 days upriver of the salt front in April-July, the months of presumed spawning (Breece *et al.* 2013). This indicates residency in low-salinity waters suitable for spawning. Collectively, the 12 Atlantic sturgeon traveled as far upstream as Roebling, NJ (RKM 201), and inhabited areas of the river ± 30 RKM from the estimated salt front for 84 percent of the time with smaller peaks occurring 60 to100 RKM above the salt front for 16 percent of the time (Breece *et al.* 2013).

Results of passive acoustic tracking of juveniles less than 2 years old indicates the area around Marcus Hook is juvenile rearing habitat. Juveniles are repeatedly present and abundant, relative to other areas of the Delaware River where receivers were located. Tracking detections have also shown that areas upriver and downriver of Marcus Hook, from approximately New Castle through Roebling, are frequented by Atlantic sturgeon juveniles, and that juveniles can travel a considerable distance in a short period of time; in excess of 20 RKM within a 24-h period (Calvo *et al.* 2010, Fisher 2011, Hale *et al.* 2016). There are also differences in juvenile movement patterns. For example, some fish remained relatively stationary during winter months while others continued to move upstream and downstream (Calvo *et al.* 2010, Fisher 2011). Additional study of juvenile Atlantic sturgeon distribution in the Delaware River estuary is in progress.

Subadult Atlantic sturgeon occur in areas of Delaware Bay and the Delaware River that differ from natal juveniles (Hilton *et al.* 2016). In some cases, subadults that originated from the Delaware River returned to the Delaware Bay and River in successive years but, in other years, tracked subadults selected other, non-natal, estuarine areas.

Characteristics of the Housatonic River relative to use by Atlantic sturgeon were described by the ASMFC (1998). The Derby Dam restricts Atlantic sturgeon access to what was likely historical habitat. Nevertheless, the reach of the river from the Derby Dam and downriver to O'Sullivan's Island has strong currents, and a mix of sand, gravel and cobble substrate. The river is tidal from the dam to the mouth of the river, where it

> discharges into Long Island Sound. The main channel of the river is approximately 5.5 meters deep from the river mouth to RKM 8, and then approximately 2 meters deep as far upriver as the Derby Dam. Atlantic sturgeon less than 100 cm total length (i.e., subadults), are present in the Housatonic River estuary during the summer months. Historical records of an Atlantic sturgeon fishery in the Housatonic River supports the presence of successful spawning (ASMFC 1998b, ASSRT 2007), and a likelihood that spawning could still occur in the Housatonic.

The action area for the proposed work considered in this Opinion covers the entire length of the Delaware River critical habitat unit. The critical habitat designation is bank-to-bank within the Delaware River. While the majority of the proposed work in designated critical habitat takes place within the Federal navigation channel, indirect effects from turbidity extend as far as 732m (mechanical dredge turbidity plume). If you were to assume a worst-case scenario where a dredge event occurred in the center of the river and the plume extended in a 732m radius around the dredge (note: we would generally expect the plume to extend only downcurrent of the dredge), the action area would encapsulate a 1,464m width of the river. In the stretch of the Delaware designated as critical habitat, the river is approximately 5,000m closest to the Bay, but quickly narrows to approximately 2,000m near New Castle, DE, and narrows further before Philadelphia (~1,000m), before reaching its narrowest points closer to Trenton, NJ (~250m). Therefore, the action area overlaps with the vast majority of the bank-to-bank critical habitat designation. Each critical habitat unit contains all four of the physical features (referred to as physical or biological features (PBF)). Therefore, the action area contains all four PBFs. Information on the PBFs within the action area is contained in the Environmental Baseline section below (Section 5.4.4).

5.0 ENVIRONMENTAL BASELINE

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

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

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

5.1.1 Crown Landing LNG Project

On May 23, 2006, we issued an Opinion to the Federal Energy Regulatory Commission (FERC) and you 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 you 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 you. As explained in the "Effects of the Action" section of this Opinion, only transient shortnose sturgeon are likely to occur in the project area and all other effects on shortnose sturgeon and their habitat are likely to be insignificant or discountable. The Opinion also concluded that the project is not likely to alter the Delaware River in a way that would make the action area unsuitable for use as a migratory pathway for any life stage of shortnose sturgeon. In the Opinion, we concluded that the proposed action was not likely to adversely affect listed sea turtles. We also concluded that the construction of the project was not likely to jeopardize the continued existence of shortnose sturgeon. 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. Should the project move forward, reinitiation of the 2006 Opinion would be necessary to consider impacts to Atlantic sturgeon and Atlantic sturgeon critical habitat (Delaware River Unit of the New York Bight DPS).

5.1.2 Salem and Hope Creek Nuclear Generating Stations

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

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

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

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

Impingement or Collection of Shortnose Sturgeon at the Trash Bars

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

Impingement or Collection of Atlantic Sturgeon at the Trash Bars

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

Life Stage	**Salem Unit 1**	**Salem Unit 2**	**Total Unit 1 and 2**
Subadult or adult SA DPS	GOM or Carolina DPS	GOM or Carolina DPS	Carolina DPS
Subadult or adult GOM DPS			
Subadult or adult Carolina DPS			

Impingement/Collection of Atlantic Sturgeon at the Traveling Screens

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

Impingement/Collection of Sea Turtles at the Trash Bars

Species	**Salem Unit 1**	**Salem Unit 2**
Loggerhead	4 (1 dead)	5 (1 dead)
Green	One at Unit 1 (alive or dead) but not more than one for Unit 1 and 2 combined	One at Unit 2 (alive or dead) but not more than one for Unit 1 and 2 combined
Kemp’s Ridley	2 (1 dead)	2 (dead)

5.1.3 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 regulations promulgated pursuant to Section 7 of the ESA, the USCG initiated emergency consultation on the effects of the cleanup action on shortnose sturgeon. In a letter dated January 20, 2006, we concluded that “while it is likely that the spill itself negatively impacted shortnose sturgeon in the Delaware River, likely by introducing contaminants into the environment and by altering normal behaviors, there is no evidence that suggests that the cleanup and response activities had an adverse effect on shortnose sturgeon. The removal of oil by mechanical means and the removal of oiled wildlife likely beneficially affected shortnose sturgeon as it minimized, to the extent possible, the potential for shortnose sturgeon to come into contact with the oil or to be contaminated by toxins through the food chain.” In this letter, we concurred with the determination made by the USCG that the response activities associated with the November 26, 2004 spill of the M/V Athos I did not adversely affect shortnose sturgeon. No oiled sturgeon or sea turtles were documented during the spill or during clean-up activities.

5.1.4 Delaware River Partners (DRP) Marine Terminal

Delaware River Partners, LLC (an applicant) seeks to develop a multiuse deep-water seaport and international logistics center on a portion of the former Dupont Repauno Property in Gibbstown, New Jersey. They require a permit from USACE to complete this work, and USACE has requested formal consultation on the project. We initiated formal consultation on August 11, 2017, and the opinion was completed on December 8, 2017.

Development includes an approach channel for vessels up to 870 feet and 30- to 40-foot deep draft, a berth with mooring dolphins, an auto terminal, a cargo area, facilities for bulk liquid energy storage, and warehouses. Estimated vessel traffic will be 133 vessel calls per year, which is 266 total vessel trips. Of these, 91 vessels are considered additional new vessels to the Delaware River while the remaining vessel activity are expected to be diverted and redistributed from existing terminals.

The development will occur on an approximately 381-acre area. Approximately 233 acres (including 29 acres in-water) of the project site is proposed to be developed into a multi-use terminal including an automobile import and processing facility, perishables and bulk cargo handling, a bulk liquid (energy liquid products) storage and handling facility, logistics and associated warehousing.

Construction activities include:

- Demolition of existing facilities and removal of in-water structures,
- filling and grading of the marine terminal area,
- construction of marine terminal buildings,
- construction of 6 outfall structures for storm water,
- dredging work (about 27 acres) within the proposed multi-purpose berth area,
- project vessel traffic
- and building of the berth including pile driving of 360 24- to 36-inch diameter hollow steel piles plus an unspecified number of smaller sized piles and sheet piles.

In addition, the proposed project included repairs and enhancements to existing site roadways and rail infrastructure, including refurbishment of existing rail lines and widening of A-Line and C-Line roadways to a maximum of 36 feet. In the biological opinion, we concluded that construction activities were not likely to adversely affect listed species. However, we did determine that the transit of roll-on/roll-off (RoRo) vessels interrelated to operation of the terminal will entrain and kill up to six adult sturgeon during the 30 years of terminal operation (until 2047). Four of these are likely to belong to the NYB DPS, one to CB DPS, and one from either SA DPS or GOM DPS. We also determined that it is likely that one adult shortnose sturgeon will be killed by RoRo vessels transiting the Delaware River during 30 years of terminal operation.

5.1.5 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 (#19331) to characterize Atlantic and shortnose sturgeon and their habitat in the Delaware River (between RKM 0 to RKM 245), determining relative abundance, recruitment, temporal-spatial distributions, and reproduction, as well as assess the potential for entrainment and impingement of sturgeon life stages at industrial intakes. Annual research activities include capturing Atlantic and shortnose sturgeon adults, sub-adults and juveniles via gill net, trammel net, trawl net, trap nets (open to the surface), or beach seine. Other general research activities on all fish include: measuring, weighing, sampling tissue (genetic analyses), scanning for tags, and inserting both Passive Integrated Transponder (PIT) and Floy/T-bar tags.

For shortnose sturgeon studies, Brundage is authorized to annually capture/re-capture a set of up to 420 adults (x >550 mm TL) sub-adults (450 > x < 550mm TL), and juveniles (x < 450mm TL), and to anesthetize two additional sets of 30 adults/sub-adults and 30 juveniles (300 mm > x < 450mm TL) and to surgically implant them with acoustic transmitters. An additional sub-set of 20 shortnose sturgeon adults/sub-adults will be tethered in a nylon sock for remote hydro-acoustic testing.

For Atlantic sturgeon, there will be an annual capture/recapture of up to 430 juveniles (x < 600mm TL), including two sub-sets of 30 juveniles (300 mm > x < 600mm TL) anesthetized and implanted with telemetry tags, and 30 anesthetized and gastric lavaged juveniles. In addition, 70 adult/sub-adult (>600mm TL) Atlantic sturgeon may be captured with a sub-set of 20 of these that tethered in a nylon sock for remote hydro-acoustic testing.

Also, annual samples of 500 early life stages of both species may be collected. There will be up to two incidental mortalities of each species (adults, sub-adults, and/or juveniles) each year, but no more than one adult of each species is anticipated during the 5-year permit. This permit expires on June 30, 2021.

Dr. Dewayne Fox of Delaware State University holds a scientific research permit (#20508 which replaces his previous permit #16507) authorizing research on Atlantic and shortnose sturgeon. Dr. Fox is authorized to use a mix of sampling techniques including gillnets, D-ring nets, egg pad collectors, biotelemetry, and hydroacoustic tools targeting both Atlantic (n=1701) and shortnose (n=501) sturgeons in mid-Atlantic ocean, bay, and river environments, specifically the Delaware River/Estuary, Hudson River/Estuary, and coastal environment between Virginia and New York, to provide much needed data focused on developing quantitative estimates of run size, recruitment, and habitat assessment. The marine Atlantic Sturgeon tagging efforts will provide the basis for population estimation work as well as help direct in-river sampling efforts for confirmation of spawning sites. In river sampling of shortnose sturgeon will primarily be focused on the collection of adults and early life stages as a means of understanding habitat requirements and developing estimates of run size. One unintentional mortality of an adult is anticipated for both sturgeon species (range-wide, any DPS for Atlantic sturgeon, as well as the directed mortality of 150 Atlantic sturgeon (NYB DPS) eggs/larvae. This permit expires on March 31, 2027.

Stonybrook and Monmouth Universities hold a research permit (#20351, replacing #16422) to continue a long term program examining the movements among and within Atlantic sturgeon marine aggregation areas located in New York, New Jersey, Delaware, and Connecticut waters.

They plan to conduct research using acoustic and conventional tagging technology to examine sex specific movements, genetic stock identification, non-invasive acquisition of diet, age, and parasite-prevalence data. Additional research will focus on targeting adults within the marine aggregation areas, as well as targeting early life stage and juvenile Atlantic and shortnose sturgeon within riverine and estuarine areas of the Hudson and Delaware Rivers. Fine scale habitat use in aggregation areas and connectivity between riverine, estuarine, and marine waters will be investigated to facilitate the development of management and conservation recommendations that serve the dual purpose of protecting Atlantic and shortnose sturgeon and maximizing stakeholder access to resources. They plan to capture 1035 Atlantic sturgeon and 470 shortnose sturgeon to meet the objectives outlined above. Within the Delaware River/Bay, one unintentional mortality of an adult (NYB DPS) Atlantic sturgeon and two unintentional mortalities of juvenile Atlantic sturgeon (NYB DPS) are anticipated. This permit expires on March 31, 2027.

Department of Natural Resources and Environmental Control (DNREC) holds a research permit (#19255, replaces #14396) to assess individual movement patterns, seasonal movements, home ranges, nursery areas, and over-wintering habitat use of juvenile life stages of Atlantic and shortnose sturgeon using passive telemetry to track movement in the Delaware River (RKM 0 to 216). They plan to generate a juvenile abundance index based on annual captures and recaptures. They propose to capture shortnose and Atlantic sturgeon using anchored gill nets, primarily in the Marcus Hook area of the Delaware River; however, their work could extend from river kilometer 90 to 165.

Annual take activities include capturing up to 50 juvenile shortnose sturgeon (<500 mm Total Length (TL)) and 10 adult/sub-adult shortnose sturgeon (>500mm TL). Concurrent takes of 175 Atlantic sturgeon juveniles (< 600 mm TL) and 10 adult/sub-adult (>600mm TL) also may occur each year. Each animal will be weighed, measured to TL, examined for tags, marked with Passive Integrated Transponder (PIT) tags, and T-bar tags, genetic tissue sampled (i.e., genetic fin clip), photographed, and released. Fifteen other juvenile (300-500 mm TL) shortnose and 30 other juvenile (300-600 mm TL) Atlantic sturgeon will be anesthetized and implanted with acoustic transmitters; 30 other juvenile Atlantic sturgeon would be gastric lavaged for diet analysis; and another 30 other Atlantic sturgeon would be fin ray sampled for age analysis. One unintentional mortality of an adult/sub-adult/juvenile of each species, annually (but not to exceed 2 adults or sub-adults of each species over the life of the permit) are anticipated. This permit expires on February 5, 2020.

5.1.6 Vessel Operations

Potential adverse effects from federal vessel operations in the action area of this consultation include operations of the U.S. Navy (USN) and the U.S. Coast Guard (USCG), which maintain the largest federal vessel fleets, the EPA, the National Oceanic and Atmospheric Administration (NOAA), and USACE. We have conducted formal consultations with the USCG, the USN, EPA and NOAA on their vessel operations. In addition to operation of USACE vessels, we have consulted with the USACE to provide recommended permit restrictions for operations of contract or private vessels around whales. Through the section 7 process, where applicable, we have and will continue to establish conservation measures for all these agency vessel operations to avoid adverse effects to listed species. Refer to the biological opinions for the USCG (September 15, 1995; July 22, 1996; and June 8, 1998) and the USN (May 15, 1997) for detail on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures. No interactions with sturgeon or sea turtles have been reported with any of the vessels considered in these Opinions. The effects of vessels (private and commercial) in the action area are further considered in Sections 5.3.2.

5.1.7 Other Federally Authorized Actions

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

5.2 State or Private Actions in the Action Area

5.2.1 State Authorized Fisheries

Atlantic and shortnose sturgeon and sea turtles may be vulnerable to capture, injury and mortality in fisheries occurring in state waters. The action area includes portions of Pennsylvania, New Jersey and Delaware state waters within the Delaware River and Delaware Bay. Information on the number of sturgeon captured or killed in state fisheries is extremely limited and as such, efforts are currently underway to obtain more information on the numbers of sturgeon captured and killed in state water fisheries. We are currently working with the Atlantic States Marine Fisheries Commission (ASMFC) and the coastal states to assess the impacts of state authorized fisheries on sturgeon. We are currently working with several states (including Delaware and New Jersey) on applications for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no permit applications have been submitted to NMFS by states that authorize fisheries within the Delaware River/Bay[7]. 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

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

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 Atlantic States Marine Fisheries Commission (ASMFC) Interstate Fisheries Management Plan (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 2011b). 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 percent CI of 3-20 (Murray 2009b). A quantitative assessment of the number of Atlantic sturgeon captured in the croaker fishery is not available. Mortality rates of Atlantic sturgeon in commercial trawls have been estimated at 5 percent. 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 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.* (2004a) 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 percent. Few Atlantic sturgeon are expected to be caught in the horseshoe crab fishery in the action area. Sea turtles are not known to be captured during horseshoe crab fishing. Shortnose sturgeon are unlikely to be captured in gear targeting horseshoe crabs given the location of fishing effort in the lower Bay.

Shad and River herring

Shad and river herring (blueback herring (*Alosa aestivalis*) and alewives (*Alosa pseudoharengus*)) are managed under an ASMFC ISFMP. 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 ISFMP, 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 percent of historical levels. Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the striped bass fishery accounted for 43 percent 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.

Sea turtle bycatch in the weakfish fishery has occurred (Murray 2009a, b, Warden 2011a, b). 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 2011b). Additional information on sea turtle interactions with gillnet gear, including gillnet gear used in the weakfish fishery, has also been 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 percent 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 percent from 1989-2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of 0.02 percent, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0 percent (ASSRT 2007).

American lobster trap fishery

An American lobster trap fishery also occurs in Delaware Bay. This fishery is managed under the Atlantic States Marine Fisheries Commission's (ASMFC) Interstate Fisheries Management Program (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. All entanglements have involved the vertical line of the gear and verified/confirmed entanglements have occurred in Maine, Massachusetts, and Rhode Island state waters from June through October (Northeast Region STDN database). While no entanglements in lobster gear have been reported for Delaware Bay, the potential for future entanglement exists. Atlantic and shortnose sturgeon are not known to interact with lobster trap gear (NMFS 2012).

5.3 Other Impacts of Human Activities in the Action Area

5.3.1 Contaminants and Water Quality

Non-point sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from urban and residential development, groundwater discharges, and industrial activities. Vessel traffic also contributes to pollutants. The Delaware Bay and River houses multiple commercial terminal and docks for recreational vessels. Consequently, the navigation channel supports a large number of commercial and private vessels. Routine discharges and leakages of fuel that occur from commercial and recreational vessels contribute hydrocarbon-based pollutants to the waters of the Delaware River and Bay.

Point source discharges (i.e., municipal wastewater, industrial or power plant cooling water or wastewater) 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.

Historically, shortnose sturgeon were rare in the area below Philadelphia, likely as a result of poor water quality (especially low dissolved oxygen concentrations), precluding migration further downstream. However, in the past 20 to 30 years, the water quality has improved, anoxic conditions during summer months no longer occur, and shortnose sturgeon have been found farther downstream (Kauffman 2010).

Though water quality in the Delaware River has improved over the last decades, water-borne contaminants are present in the action area, albeit at reduced levels (Kauffman 2010). Large portions of the Delaware River are bordered by highly industrialized waterfront development. Sewage treatment facilities, refineries, manufacturing plants and power generating facilities all intake and discharge water directly from the Delaware River. This result in large temperature variations and the presence of heavy metals, dioxin, dissolved solids, phenols and hydrocarbons which may alter the pH of in the water that may eventually lead 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. Contaminants have been detected in Delaware River fish with elevated levels of PCB in several species of fish. Thus, it is possible that the presence of contaminants in the action area have adversely affected sturgeon abundance, reproductive success and survival, but it is difficult to detect or evaluate such effects.

Several characteristics of 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 fish, such as sturgeon, that feed on benthic organisms (Varanasi 1992). 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 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 (Hansen *et al.* 1985, Mac and Edsall 1991, Von Westernhagen *et al.* 1981), 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 Atlantic sturgeon and shortnose sturgeon tissues, some research on other, related species indicates that concern about effects of contaminants on the health of sturgeon populations is warranted. Detectable levels of chlordane, DDE, DDT, and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (US Fish and Wildlife Service 1993). These compounds may affect physiological processes and impede a fish's ability to withstand stress. PCBs are believed to adversely affect reproduction in pallid sturgeon (Ruelle and Keenlyne 1993). Ruelle and Henry (1992) found a strong correlation between fish weight $r = 0.91$, $p < 0.01$), fish fork length $r = 0.91$, $p < 0.01$), and DDE concentration in pallid sturgeon livers, indicating that DDE concentration increases proportionally with fish size.

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002).

Sixteen metals, two semi-volatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs and DDE (an organochlorine pesticide) were detected in the "adverse effect" range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. While no directed studies of chemical contamination in sturgeon in the Delaware River have been undertaken, it is evident that the heavy industrialization of the Delaware River is likely adversely affecting the Atlantic sturgeon and shortnose sturgeon populations.

Chemical contaminants may also have an effect on sea turtle reproduction and survival. While the effects of contaminants on turtles are relatively unclear, pollution may be linked to the fibropapilloma virus that kills many turtles each year (Singel *et al.* 2003). If pollution is not the causal agent, it may make sea turtles more susceptible to disease by weakening their immune systems. 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. Excessive turbidity due to coastal development and/or construction sites could influence sea turtle foraging ability. Sea 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 listed species. Private cargo vessels transit the Delaware River annually, as well as numerous smaller commercial and recreational vessels.

You provided the following data in the Biological Assessment for the Delaware River Partners project (2017a), described in Section 5.1.4. Given the overlap of action areas, the information is also relevant for the Philadelphia to Sea FNP portion of this Opinion:

> The number of cargo vessels per year using the Delaware River is expected to increase in the absence of any new port facilities (Altiok *et al.* 2012). The annual percentage increase in vessel arrival rates is estimated between 1.0 percent and 2.5 percent for general and container cargo types in the years 2010 to 2020 (Altiok *et al.* 2012). The annual number of containership, bulk, and general cargo vessels will increase by 75 percent from 1,162 (baseline 2004 through 2008) to 2,037 in 2038, based on a 30-year vessel traffic simulation (Altiok *et al.* 2012). As a result of the recent Panama Canal Expansion (completed June 2016), maritime traffic and the size of ships is expected to generally increase in routes along the U.S. Atlantic Coast from 5,000 twenty-ft equivalent unit ("TEU") vessels to vessels of up to 13,000 TEU (MARAD 2013). Further, the Northeast Asia to US East Coast route is the most likely to be impacted by canal expansion. Cost reductions caused by canal expansion could divert shipments away from the West Coast

> into East coast ports (MARAD 2013), which would increase traffic at east coast ports.
>
> USACE publishes data on waterborne traffic movements involving the transport of goods on navigable waters of the U.S. In 2015, there were 25,766 upbound and 25,808 downbound vessel movements within the Federal navigation channel between Philadelphia, PA and the Delaware Bay. The total number of vessel trips (upbound + downbound) was 51,574. These data represent the most recent year that published data was available and include both small and large ships with varying drafts. This number represents the best available estimate of traffic within the Action Area. The estimate excludes recreational and other non-commercial vessels, ferries, or any Department of Defense vessels (i.e., USN, USCG, etc.). Therefore, this number likely underestimates the total annual vessel traffic within the Delaware River. There is significant uncertainty in estimating the total amount of non-commercial vessel traffic in the Action Area. In general, recreational vessel traffic is seasonal with peak traffic occurring between the Memorial Day and Labor Day holidays (Anonymous).

From Philadelphia to Trenton, the USACE Navigation Data Center reports that for calendar year 2012 – calendar year 2016, the number of commercial vessel trips (inclusive of both upriver and downriver trips) in this portion of the river (from Alleghany Avenue in Philadelphia to Trenton) ranged from a high of 4,100 trips in 2015 to a low of 5,384 in 2014[8]. This includes domestic and international vessels inclusive of self-propelled dry cargo, self-propelled tanker, self-propelled towboat, nonself-propelled dry cargo and non-self-propelled liquid tanker barge. Vessel drafts ranged from 1-43 feet with the vast majority in the 2-12 foot range.

The largest commercial vessels (e.g., oil tankers, container and bulk carriers, etc.) range in length between 800’ and 1100’ with beam widths between 100’ and 200’, and pass throughout the navigation channel daily. Approximately 3,000 deep draft vessels (tanker ships are greater than 125,000 deadweight tons) enter the river each year (DRBC 2017b). Upon approaching the channel in the lower Delaware Bay, many oil tankers have drafts exceeding 45 feet. They are required to pay for lightering, where some of the oil is pumped off the vessel to get the draft to a point where the vessel can pass upriver during high tide, with required 2-feet of clearance. Most of the largest tankers make their port calls before the Walt Whitman Bridge in Philadelphia, but many large, deep draft vessels (e.g., bulk salt/gypsum, fertilizer, and scrap metal vessels) use the extent of the 40-foot channel to Fairless Terminal which is approximately 5 miles below Trenton, New Jersey. Given the size of the vessels and the proximity of the propeller to the bottom of the channel, there is a fairly constant disturbance regime where areas of mobile soft substrates are disturbed or displaced by the water that displaced by large propellers (i.e., prop wash) as these large vessels move throughout the navigation channel from Trenton to the Sea. This results in temporary, localized increased levels of turbidity and total suspended sediments that move up or downstream with the vessel. Vessels occasionally strike shoaled areas, but are still able to pass through. At least a couple of times per week, large tankers actually pass side by side as one travels upstream and the other down. In these instances, they require use of the entire

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[8] http://www.navigationdatacenter.us/wcsc/webpub/#/report-landing/year/2016/region/1/location/5232; last accessed November 15, 2017

800’ wide channel, likely causing at least some sediment disturbance throughout the channel and beyond, with the extent and duration likely limited by substrate type, vessel/propeller size, and tidal/flow conditions at the time (pers. comm. Charles Myers, USACE, 10/24/2017).

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.

The factors relevant to determining the risk to Atlantic and shortnose sturgeon from vessel strikes are currently unknown, but based on what is known for other species we expect they are related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of sturgeon in the area (e.g., foraging, migrating, etc.). Geographic conditions (e.g. narrow channels, restrictions, etc.) may also be relevant risk factors. Large vessels have been typically implicated because of their deep draft relative to smaller vessels, which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). However, a 35-foot recreational vessel travelling at 33 knots on the Hudson River was reported to have struck and killed a 5.5 foot Atlantic sturgeon (NYSDEC sturgeon mortality database (9-15-14)). Given these incidents, we conclude that interactions with vessels are not limited to large, deep draft vessels.

Data combined from Delaware’s Department of Natural Resources and Environmental Control (DNREC) and the Atlantic sturgeon salvage program from recovered carcasses in the Delaware River and Estuary indicate that between 2005 and 2016, 92 sturgeon mortalities were attributable to vessel strikes (an additional 47 had an unknown cause of death).

Sea turtles are known to be vulnerable to vessel strikes. In 1990, the National Research Council estimated that 50-500 loggerhead and 5-50 Kemp’s ridley sea turtles were struck and killed by boats annually in waters of the U.S. (NRC 1990). The report indicates that this estimate is highly uncertain and could be a large overestimate or underestimate. As described in the Recovery Plan for loggerhead sea turtles (NMFS and USFWS 2008), propeller and collision injuries from boats and ships are common in sea turtles. From 1997 to 2005, 14.9 percent of all stranded loggerheads in the U.S. Atlantic and Gulf of Mexico were documented as having sustained some type of propeller or collision injuries although it is not known what proportion of these injuries were post or ante-mortem. Stetzar (2002) reports that 24 of 67 sea turtles stranded along the Atlantic Delaware coast from 1994-1999 had evidence of boat interactions (hull or propeller strike); however, it is unknown how many of these strikes occurred after the sea turtle died. If we assume that all were struck prior to death, this suggests a minimum of four strikes per year in this area. Stetzar (2002) reports that 33 of 109 sea turtles stranded along the Delaware Estuary from 1994-1999 had evidence of boat interactions (hull or propeller strike); however, it is unknown how many of these strikes occurred after the sea turtle died. If we assume that all were struck prior to death, this suggests 5 to 6 strikes per year in the Delaware Estuary. The Marine Mammal Stranding Center responds to stranded sea turtles in New Jersey. From January through September, 2018, they responded to 43 sea turtles. Of these, 10 (7 loggerhead and 3 Kemp’s ridley) had evidence of interactions with vessels (boat or propeller strike).[9] As noted in NRC 1990, the regions of greatest concern for vessel strike are outside the action area and include areas with high concentrations of recreational-boat traffic such as the eastern Florida coast, the Florida Keys, and the shallow coastal bays in the Gulf of Mexico. In general, the risk of strike for sea turtles is considered to be greatest in areas with high densities of sea turtles and small, fast moving vessels such as recreational vessels or speed boats (NRC 1990).

5.4 Summary of Available Information on Listed Species and Critical Habitat in the Action Area

5.4.1 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 due to low salinity; 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. 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 1994). The areas to be dredged and the depths preferred by sea turtles do overlap, suggesting that if suitable forage was present, adult and juvenile loggerheads, juvenile Kemp's ridleys, and juvenile green sea turtles 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, primarily herbivorous adult green sea turtles are not likely to use the areas to be dredged for foraging.

5.4.2 Shortnose Sturgeon

Shortnose sturgeon occur in the Delaware River from the lower bay upstream to at least Lambertville, New Jersey (RKM 238). Tagging studies by O'Herron *et al.* (1993) found that the most heavily used portion of the river appears to be between RKM 190 below Burlington Island

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[9] https://mmsc.org/strandings/stranding-stats. Last accessed 12/05/2018

and RKM 220 at the Trenton Rapids. Hastings *et al.* (1987) used Floy T-anchor tags in a tag-and-recapture experiment from 1981 to 1984 to estimate the size of the Delaware River population in the Trenton to Florence reach. Population sizes by three estimation procedures ranged from 6,408 to 14,080 adult sturgeon. These estimates compare favorably with those based upon similar methods in similar river systems. This is the best available information on population size, but because the recruitment and migration rates between the population segment studied and the total population in the river are unknown, model assumptions may have been violated.

In the Delaware River, movement to the spawning grounds occurs in early spring, typically in late March[10], with spawning occurring through early May, and sturgeon typically leaving the spawning grounds by the end of 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 15ºC. Studies conducted between 2007 and 2013 indicate that shortnose sturgeon utilize at least a 22 km reach of the non-tidal river from Trenton rapids to the Lambertville rapids for spawning. Spawning activity is likely greatest in the rapids and high velocity run areas, such as those below the Lambertville wing dam and Scudders Falls. However, some spawning activity may occur throughout the reach, since much of it features clean cobble/gravel substrate and at least moderate current velocities suitable for shortnose sturgeon spawning. The spawning area is well upstream of the Philadelphia to Trenton channel. The capture of early life stages (eggs and larvae) in this region in the spring of 2008 confirms that this area of the river is used for spawning and as a nursery area (ERC 2009). During the spawning period, males remain on the spawning grounds for approximately a week while females only stay for a few days (O'Herron and Hastings 1985). After spawning, which typically ceases by the time water temperatures reach 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 adhere to the substrate in the spawning area quickly after being deposited. Development of eggs depends on water temperature, with hatch times ranging from approximately 8-13 days post spawn (Buckley and Kynard 1981, Dadswell *et al.* 1984). The yolk-sac larvae phase lasts approximately 8-12 days and is characterized by "swim up and drift" behavior. Yolk-sac larvae are photonegative, seek cover in hard substrate, and remain near the spawning site. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment. Larvae are expected to be less than 20mm TL at this time (Richmond and Kynard 1995). Post yolk-sac larvae begin feeding (on aquatic insects, insect larvae and other invertebrates) and are free-swimming; they disperse downstream of the

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[10] 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.

spawning/rearing area. The post-yolk sac larvae phase ends at about 40 days post-hatch. Post yolk-sac larvae are typically found in the deepest water available (Bath *et al.* 1981, Kieffer and Kynard 1993, Taubert and Dadswell 1980). Different studies have documented different preferred substrate (Parker 2007, Richmond and Kynard 1995). Post yolk-sac larvae are intolerant of salinity; therefore, they occur only in freshwater (Dadswell *et al.* 1984, Kynard 1997, SSSRT 2010). This initial downstream migration generally lasts two to three days (Richmond and Kynard 1995). Studies (Kynard and Horgan 2002) suggest that post yolk-sac larvae move approximately 7.5km/day during this initial 2 to 3 day migration. Laboratory studies indicate that these young sturgeon move downstream in a 2-step migration: the initial 2-3 day migration followed by a residency period of the young-of-year (YOY), then a resumption of migration by yearlings in the second summer of life (Buckley and Kynard 1981).

In other river systems, older juveniles (3-10 years old) occur in the saltwater/freshwater interface (NMFS 1998). In these systems, juveniles moved back and forth in the low salinity portion of the salt wedge during summer. In the Delaware River the salt front can range from as far south as Wilmington, Delaware, north to Philadelphia, Pennsylvania, depending upon meteorological conditions such as excessive rainfall or drought. The salt front location varies throughout the year, with the median monthly salt front ranging from RKM 107.8 to RKM 122.3 (DRBC 2017). As a result, it is possible that in the Delaware River, juveniles could range from Artificial Island (RKM 87) to the Schuylkill River (RKM 148) (O'Herron 2000, pers. comm.). Acoustic tracking of tagged juveniles indicates that juveniles are likely overwintering in the lower Delaware River from Philadelphia to below Artificial Island (ERC 2007). The distribution of juveniles in the river is likely highly influenced by flow and salinity. In years of high flow (for example, due to excessive rains or a significant spring runoff), the salt wedge will be pushed seaward and the low salinity reaches preferred by juveniles will extend further downriver. In these years, shortnose sturgeon juveniles are likely to be found further downstream in the summer months. In years of low flow, the salt wedge will be higher in the river and in these years juveniles are likely to be concentrated further upstream.

O'Herron believes that if juveniles are present within this range they would likely aggregate closer to the downstream boundary in the winter when freshwater input is normally greater (O'Herron 2000, pers. comm.). Research in other river systems indicates 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 (~RKM 161). After adult sturgeon migrate to the area around Philadelphia, many adults return upriver to between RKM 204 and 216 within a few weeks, while others gradually move to the same area over the course of the summer (O'Herron *et al.* 1993). By the time water temperatures have reached 10°C, typically by mid-November[11], most adult sturgeon

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[11] 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).

have returned to the overwintering grounds around Duck Island and Newbold Island. These patterns are generally supported by the movement of radio-tagged fish in the region between RKM 201 and RKM 238 as presented by Brundage (1986). Based on water temperature data collected at the USGS gage at Philadelphia, in general, shortnose sturgeon are expected to be at the overwintering grounds between early November and mid-April. A large number of adult shortnose sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between RKM 190 and 211. The areas around Duck Island and Newbold Island seem to be regions of intense overwintering concentrations. However, unlike sturgeon in other river systems, there is some evidence that shortnose sturgeon in the Delaware do not always remain stationary during overwintering periods. O'Herron *et al.* (1993) found that the typical overwintering movements are fairly localized. They describe one tagged shortnose sturgeon in the Duck Island area that made movements over a 1.7 km range from mid-November into December, suggesting, at least in this case, a concentrated range for overwintering, but not completely sedentary activity. Investigations with video equipment by the USACE in March 2005 (USACE 2008) 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 majority of adult shortnose sturgeon overwinter near Duck and Newbold Island but that a limited number of shortnose sturgeon occur in other downstream areas, including Marcus Hook, during the winter months.

Brundage and O'Herron (2014a) carried out a relocation trawl pilot study in the Marcus Hook Anchorage (RKM 127-139) from January 25-March 7, 2014. Captured fish were relocated to the Ft. Mifflin (RKM 147), Torresdale (RKM 176), and Burlington (RKM 193) ranges of the Delaware River. While trawling, they collected 67 shortnose sturgeon (48 adults, 19 juveniles), indicating that the Marcus Hook area is used by adult as well as juvenile shortnose sturgeon. Overwintering juveniles are expected to occur on the freshwater side of the salt front (O’Herron 1990).

Since the 2015 Opinion was finalized, three relocation trawling and blasting seasons have occurred from November 15 – March 15 (2015-2016, 2016-2017, 2017-2018). During the 2015-2016 season, 111 shortnose sturgeon were captured in the general blasting area (Reach B, ~RKM 108-136.8) and relocated upstream between the Bridesburg Channel, Roebling, and Bordentown, New Jersey (RKM 169.8-207)(ERC 2016). In the second season (2016-2017), 300 shortnose sturgeon were captured in the general blasting area, and relocated upriver between Burlington and Roebling, New Jersey (RKM 190-199)(ERC 2017). And, in the third season (2017-2018), 486 shortnose sturgeon were captured in the general blasting area, and relocated upriver between Burlington and Roebling, New Jersey (RKM 190-199), though some were released further downstream in January because of severe icing of the river (ERC 2018). In their end of season reports, ERC (2017, 2018) presented length-frequency distributions for captured shortnose sturgeon. The number of juveniles varied between the two last seasons. During the 2016-2017 season, 23 percent were considered juveniles and in the 2017-2018 season, nine percent were considered juveniles (ERC 2017, 2018). The report for the first season does not provide information on the proportion of juveniles caught (ERC 2016). The juvenile catch also included at least two age 0 (2016 year class, or young-of-year)) in the second season and 13 age 0 (2017 year class, or young-of-year)) in the third season. These data further demonstrate the use of Reach B by juvenile, including young-of-year, and adult shortnose sturgeon throughout the winter months (see Figure 7, below).

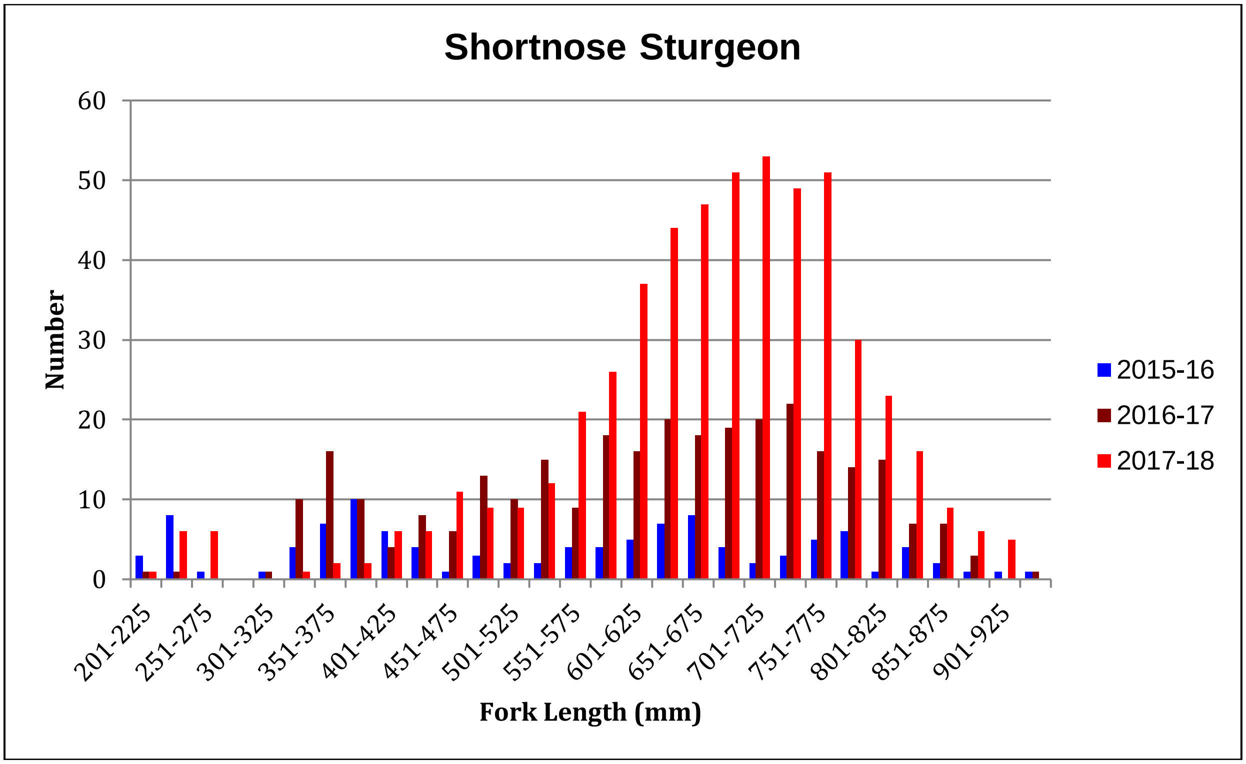

Figure 8. Length – Frequency Distribution of Shortnose Sturgeon Collected During Relocation Trawling, December 2015 – February 2018 (graph provided by Hal Brundage)

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

Historically, sturgeon were relatively rare below Philadelphia due to poor water quality. Since the 1990s, the water quality in the Philadelphia area has improved leading to an increased use of the lower river by shortnose sturgeon. Few studies have been conducted to document the use of the river below Philadelphia by sturgeon. Brundage and Meadows (1982) have reported incidental captures in commercial gillnets in the lower Delaware. During a study focusing on

Atlantic sturgeon, Shirey *et al.* (1999) captured 9 shortnose sturgeon in 1998. During the June through September study period, Atlantic and shortnose sturgeon were found to use the area on the west side of the shipping channel between Deep Water Point, New Jersey and the Delaware-Pennsylvania line. The most frequently utilized areas within this section were off the northern and southern ends of Cherry Island Flats in the vicinity of the Marcus Hook Bar. A total of 25 shortnose sturgeon have been captured by Shirey in this region of the river from 1992 - 2004, with capture rates ranging from 0-10 fish per year (Shirey 2006). Shortnose sturgeon have also been documented at the trash racks of the Salem nuclear power plant in Salem, New Jersey at Artificial Island.

In May 2005, a one-year survey for juvenile sturgeon in the Delaware River in the vicinity of the proposed Crown Landing LNG project was initiated. The objective of the survey was to obtain information on the occurrence and distribution of juvenile shortnose and Atlantic sturgeon near the proposed project site to be located near RKM 126, approximately 32 kilometers south of Philadelphia. Sampling for juvenile sturgeon was performed using trammel nets and small mesh gill nets. The nets were set at three stations, one located adjacent to the project site, one at the upstream end of the Marcus Hook anchorage (approximately 4 kilometers upstream of the project site, at RKM 130), and one near the upstream end of the Cherry Island Flats (at RKM 119; approximately 6 kilometers downstream of the site). Nets were set within three depth ranges at each station: shallow (<10 feet at MLW), intermediate (10-20 feet at MLW) and deep (20-30+ feet at MLW). Each station/depth zone was sampled once per month. Nets were set for at least 4 hours when water temperatures were less than 27°C and limited to 2 hours when water temperature was greater than 27°C. The sampling from April through August 2005 yielded 3,014 specimens of 22 species, including 3 juvenile shortnose sturgeon. Juvenile shortnose sturgeon were collected during the June, July and August, one fish in each of the sampling events. Two of the shortnose sturgeon were collected at RKM 126 and one was taken at the downstream sampling station at RKM 119. Total length ranged from 311-367mm. During the September – December sampling, one juvenile shortnose sturgeon was caught in September at RKM 126 and one in November at the same location. One adult shortnose sturgeon was captured in October at RKM 119. All of the shortnose sturgeon were collected in deep water sets (greater than 20 feet). These depths are consistent with the preferred depths for foraging shortnose sturgeon juveniles reported in the literature (NMFS 1998). The capture of an adult in the Cherry Island Flats area (RKM 119) is consistent with the capture location of several adult sturgeon reported by (Shirey *et al.* 1999) and Shirey (2006).

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

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

In 2005, USACE conducted investigations to determine the use of the Marcus Hook region by sturgeon (USACE 2008). Surveys for the presence of Atlantic and shortnose sturgeon were conducted between March 4 and March 25, 2005 primarily using a Video Ray® Explorer submersible remotely operated vehicle (ROV). The Video Ray® was attached to a 1.0 x 1.0 x 1.5 meter aluminum sled which was towed over channel bottom habitats behind a 25-foot research boat. All images captured by the underwater camera were transmitted through the unit's electronic tether and recorded on video cassettes. A total of 43 hours of bottom video were collected on 14 separate survey days. Twelve days of survey work were conducted at the Marcus Hook, Eddystone, Chester, and Tinicum ranges, while two separate days of survey work were conducted up river near Trenton, New Jersey, at an area known to have an overwintering population of shortnose sturgeon.

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

Limited 25-foot otter trawling and gillnet sets were conducted initially to provide density data, and later to provide ground truth information on the fish species seen in the video recording. Large boulders and other snags that tore the net and hung up the vessel early on in the study prompted abandoning this effort for safety reasons given the high degree of tanker traffic in the lower Delaware River. The trawl net was a 7.6-m (25-foot) experimental semi-balloon otter trawl with 44.5-mm stretch mesh body fitted with a 3.2-mm stretch mesh liner in the cod end. Otter trawls were generally conducted for five minutes unless a snag or tanker traffic caused a reduction in tow time. Experimental gillnets were periodically deployed throughout the survey period in the Marcus Hook area. One experimental gillnet was 91.4-m in length and 3-m deep and was composed of six 15.2-m panels of varying mesh size. Of the six panels in each net, two panels were 50.8-mm stretch mesh, 2 panels were 101.6-mm stretch mesh and 2 panels were 152.4-mm stretch mesh. Another gillnet was 100 m in length and consisted of four 25 x 2-m panels of 2.5-10.2-cm stretched monofilament mesh in 2.5 cm increments. Gill nets were generally set an hour before slack high or low water and allowed to fish for two hours as the nets had to be retrieved before maximum currents were reached.

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

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

The results of the video sled survey in the Marcus Hook project area confirmed that sturgeons are using the area in the winter months. However, sturgeon relative densities in the project area were much lower than those observed near Trenton, New Jersey, even when the upriver counts were adjusted for the higher visibility (i.e., between runner sturgeon counts). The sturgeon seen near Trenton were very much concentrated in several large aggregations, which were surveyed in multiple passes on the two sampling dates devoted to this area. The lack of avoidance of the approaching sled seen in the upriver video recordings where water clarity was good suggests that little to no avoidance of the sled occurred in the low visibility downriver project area. Video surveys in the downriver project area did not encounter large aggregations of sturgeon as was observed in the upstream survey area despite having five times more sampling effort than the upstream area. This suggests that sturgeon that do occur in the Marcus Hook area during the winter are more dispersed and that the overall number of shortnose sturgeon occurring in this area in the winter months is low.

However, results from the relocation trawl pilot study carried out in 2014 and subsequent relocation trawling efforts in 2015-2018, indicate that adult and juvenile shortnose sturgeon are present in the Marcus Hook area during the winter in larger numbers than previously predicted. In less than 8 hours of trawling, 67 shortnose sturgeon were collected. Tagged shortnose sturgeon were also detected in the Marcus Hook area during a sound deterrent test carried out from March 21 – May 7. Shortnose sturgeon present at Marcus Hook during the winter do appear to be more active than shortnose sturgeon documented at the upriver overwintering sites; therefore, there could have been greater avoidance behavior at Marcus Hook which could account for the lower detection on the video. It is also possible that the number of shortnose sturgeon at Marcus Hook varies annually. The time of year that the video survey was carried out (March 4-March 25) is similar to the time of year the trawl survey took place (February 25 to March 7); therefore, it does not appear that the difference is a result of the timing of the survey. Based on this new information, we expect juvenile and adult shortnose sturgeon in the Marcus Hook area during the winter months; however, we do not expect them to occur in dense, sedentary aggregations as is seen in the upriver overwintering sites.

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

Although they have been documented in waters with salinities as high as 31 parts per thousand (ppt), shortnose sturgeon are typically concentrated in areas with salinity levels of less than 3 ppt (Dadswell *et al.* 1984). Jenkins *et al.* (1993) demonstrated in lab studies that 76-day old shortnose sturgeon experienced 100 percent 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 percent mortality at salinity levels of 30 ppt. A salinity of 9 ppt appeared to be a threshold at which significant mortalities began to occur, especially among the youngest fish (Jenkins *et al.* 1993). The distribution of salinity in the Delaware estuary exhibits significant variability on both spatial and temporal scales, and at any given time reflects the opposing influences of freshwater inflow from tributaries versus saltwater inflow from the Atlantic Ocean. The estuary can be divided into four longitudinal salinity zones. Starting at the downstream end, the mouth of the Bay to RKM 55 is considered polyhaline (18-30ppt), RKM 55-71 is mesohaline (5-18ppt), RKM 71-127 is oligohaline (0.5-5ppt), and Marcus Hook (RKM 127) to Trenton is considered Fresh (0.0-0.5ppt). Based on this information and the known tolerances and preferences of shortnose sturgeon to salinity, shortnose sturgeon are most likely to occur upstream of RKM 70 where salinity is typically less than 5ppt. As tolerance to salinity increases with age and size, large juveniles and adults are likely to be present through the mesohaline area extending to RKM 55. Due to the typical high salinities experienced in the polyhaline zone (below RKM 55), shortnose sturgeon are likely to be rare in this reach of the river; this area covers Reach E.

5.4.2.1 Expected Seasonal Distribution of Shortnose Sturgeon from Philadelphia to the Sea (Reaches E, D, C, B, A, AA)

The discussion below summarizes the likely seasonal distribution of shortnose sturgeon in the river reaches (see Table 1). Based on salinity and the best available information on spawning locations, eggs and larvae are not likely to be in Reaches E-AA. Due to the benthic, adhesive nature of the eggs, they only occur in the immediate vicinity of the spawning area. Yolk-sac larvae are also limited to an area close to the spawning grounds, and therefore, not likely to occur in these reaches. Distribution of adult and juvenile shortnose sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity.

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

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

Reach C encompasses the area from RKM 89-107.8 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, adult and juvenile shortnose may be present in this reach of the river year round.

Reach B (RKM 108-136.8) encompasses the Cherry Island Flats and Marcus Hook Bar areas. The capture of multiple shortnose sturgeon in this reach during the summer months (Shirey 2006, Shirey *et al.* 1999) 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 shortnose sturgeon may overwinter near Marcus Hook, or that at least that some shortnose sturgeon are present in this area during the winter (Brundage and O'Herron 2014b, Brundage and O'Herron 2009, ERC 2012, 2017, 2018, USACE 2008). Adult and juvenile shortnose sturgeon were collected in a trawl operating in the Marcus Hook, Eddystone, Chester and Tinicum ranges from February 25 – March 7, 2015. As such, adult, juvenile, and young-of-year shortnose sturgeon could be present in Reach B year round.

Similarly, Reach A (RKM 137-156.1) is also likely to be used by migrating shortnose sturgeon and for opportunistic foraging. This reach of the river includes the Torresdale Range (RKM 150), an area which the 2003-2004 telemetry study noted above suggests may be a relatively high use area for shortnose sturgeon in the April – October time frame. The number of shortnose sturgeon utilizing the Torresdale area suggests that conditions in Torresdale may support a shortnose sturgeon foraging or resting area; however, the tracking data indicates that shortnose sturgeon in this reach are highly mobile. We expect young-of-year, juvenile, and adult shortnose sturgeon in Reach A year round.

Both adult and juvenile shortnose sturgeon occur in Reach AA (RKM 156.3-164.2) 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[12]. 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

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[12] 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.

shortnose sturgeon. As evidenced by tracking (Brundage and O'Herron 2014b, ERC 2007), some juvenile and adult shortnose sturgeon and juvenile Atlantic sturgeon are also likely to move through Reach AA during the winter. Therefore, we expect that young-of-year, juvenile, and adult shortnose sturgeon will occur in Reach AA year-round.

5.4.2.2 *Expected Seasonal Distribution of Shortnose Sturgeon from Philadelphia to Trenton (Reaches A-B, B-C, C-D)*

Reach A-B encompasses (RKM 176.9-204.2) the stretch of river USACE defines as Allegheny Ave. (Philadelphia) to Burlington Island, as well as Burlington Island to Newbold Island (Bucks County). These reaches also include the Fairless Turning Basin, which USACE separates as an individual contract. As noted above, after spawning (non-tidal river from Trenton rapids (~ RKM 214) to the Lambertville rapids (~RKM 238)), adult shortnose sturgeon migrate rapidly downstream to the Philadelphia area (~RKM 161). After adult sturgeon migrate to the area around Philadelphia, many adults return upriver to between RKM 204 and 216 within a few weeks, while others gradually move to the same area over the course of the summer (O'Herron *et al.* 1993). By the time water temperatures have reached 10°C, typically by mid-November[13], most adult sturgeon have returned to the overwintering grounds around Duck Island (~RKM 208) and Newbold Island (~RKM 201), although the overwintering grounds may extend as far as the Moon Channel (~ RKM 212). These patterns are generally supported by the movement of radio-tagged fish in the region between RKM 201 and RKM 238 as presented by Brundage (1986). Based on water temperature data collected at the USGS gage at Philadelphia, in general, shortnose sturgeon are expected to be at the overwintering grounds between early November and mid-April. A large number of adult shortnose sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between RKM 190 and 211.

As described above, eggs and yolk-sac larvae remain near the spawning site (located approximately 10 RKM upstream of Reach A-B), and will therefore not be in Reach A-B. Post yolk-sac larvae (a phase which lasts ~40 days post hatch), could be in Reach A-B from mid-April until the nearly the end of July. Young-of-year, juvenile, and adult shortnose sturgeon may be present in Reach A-B year-round as they migrate between foraging, overwintering, and spawning grounds. Overwintering aggregations occur within this reach at Newbold Island.

Reach B-C encompasses (RKM 207.1-212.5) the stretch of river USACE defines as Newbold Island to Trenton Marine Terminal. Again, we would not expect shortnose sturgeon eggs or yolk-sac larvae in this Reach, but post yolk-sac larvae could be in Reach B-C from mid-April until the end of July. Young-of-year, juvenile, and adult shortnose sturgeon may be present in Reach B-C year-round as they migrate between foraging, overwintering, and spawning grounds. Overwintering aggregations occur within this reach at Duck Island.

Reach C-D encompasses RKM 212.5-214.5. USACE does not routinely maintain this contract (it has not been dredged in over 30 years), and the channel is for recreational river use only.

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[13] 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).

Shortnose sturgeon spawning may occur in the uppermost part of this reach, and therefore eggs and yolk-sac larvae may occur in this reach from mid to late March until the end of June (adults exiting the spawning grounds by the end of May, plus an additional thirty days to accommodate the egg development, hatching, and yolk-sac larval stage). Post yolk-sac larvae could be present for an additional month, until the nearly the end of July. While it is possible young-of-year and juvenile shortnose sturgeon could be in this reach, it does not contain a known overwintering aggregation site, and those life stages would likely be further downstream for foraging and overwintering. Adults would likely only be present in this reach during the spawning months.

5.4.3 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 almost 220 km (Hilton *et al.* 2016, Simpson 2008). All historical Atlantic sturgeon habitats appear to be accessible in the Delaware (ASSRT 2007); however, given upstream shifts in the saltwedge over time, there are not currently as many river miles of freshwater available to Atlantic sturgeon compared to pre-industrial times.

Historical records from the 1830s indicate Atlantic sturgeon may have spawned as far north as Bordentown, just below Trenton, NJ (Pennsylvania Commission of Fisheries, 1897). Cobb (1899) and Borodin (1925) reported spawning between RKM 77 and 130 (Delaware City, DE to Chester City, PA). Based on tagging and tracking studies, Atlantic sturgeon spawning may occur upstream of the salt front over hard bottom substrate between Claymont, DE/Marcus Hook, PA (Marcus Hook Bar), approximately RKM 125, and the fall line at Trenton, NJ, approximately RKM 212 (Breece *et al.* 2013, Simpson 2008). The shift from historical spawning sites is thought to be at least partially related to changes in the location of the salt line over time. Hard bottom habitat believed to be appropriate for sturgeon spawning (gravel/coarse grain depositional material and cobble/boulder habitat) occurs between the Marcus Hook Bar (RKM 125) and the mouth of the Schuylkill River (RKM 148) (Breece *et al.* 2013, Sommerfield and Madsen 2003). Tracking of ten male and two female sturgeon belonging to the New York Bight DPS and presumed to be adults based on their size (> 150 centimeter fork length) indicated that each of the 12 sturgeon spent 7 to 70 days upriver of the salt-front, in April-July, the months of presumed spawning (Breece *et al.* 2013). This indicates residency in low-salinity waters suitable for spawning. The sturgeon selected areas with mixed gravel and mud substrate (Breece *et al.* 2013). Collectively, the 12 Atlantic sturgeon traveled as far upstream as Roebling, NJ (RKM 201), and inhabited areas of the river ± 30 kilometers from the estimated salt front for 84 percent of the time with smaller peaks occurring 60 to 100 kilometers above the salt front for 16 percent of the time (Breece *et al.* 2013).

An unpublished 2013 telemetry study, the results of which were presented at the 2015 annual meeting of North American Sturgeon and Paddlefish Society (Oshkosh, WI) by DiJohnson *et al.* (2015), recorded the movements of seven spawning condition Atlantic sturgeon adults in the Delaware River's Eddystone and Tinicum ranges (~RKM 133-138).

The researchers chose the array's location because of their prior work in this area and previous studies conclusions (e.g., Breece *et al.* 2013) which confirmed that the area had the hard bottom habitat necessary for Atlantic sturgeon spawning. This habitat, made up of outcrops of bedrock and non-depositional, mixed grained material (i.e., hard but not stationary), occurs both within the navigation channel and along the northern edge of the channel near the Eddystone Range.

The researchers deployed the array, consisting of VR2W receivers collocated with synchronization tags to form VEMCO Positioning System (VPS), from April 15 - July 1, 2013, and captured data showing the seven spawning condition adults arriving in the array in late April - mid May (2013) and last detecting them in the array from late May to early June.

The fish occupied this area for an average of 4.8 days, demonstrating an affinity for the northern edge of the navigation channel near Eddystone (Pers. comm. with Dewayne Fox, 10/30/2017). During the study, the researchers tracked vessel traffic movements using AIS data, recording 397 individual vessels while the array was deployed, 138 of which co-occurred with times of tagged sturgeon activity. The vessels averaged 17 km/hr and 52 percent were large, deep-draft vessels.

The results indicate that Atlantic sturgeon likely use the reach of the river where the array was deployed for spawning, but also face significant daily threats from vessel traffic, particularly deep draft vessels, both from propeller strikes (of adults) and indirect effects on early life stages (eggs and larvae) from prop wash and suspended sediments.

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 (Calvo *et al.* 2010, Fisher 2009). 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).

Brundage and O’Herron (2014a) provided further evidence of the use of Marcus Hook area during winter months. Their trawl survey along RKM 127-139 from January 25-March 7, 2014 collected 36 Atlantic sturgeon (7 juveniles, 29 YOY). Prior to and during the first blasting season

(November 15, 2015-March 15, 2016), 775 Atlantic sturgeon were captured in the blasting area, ranging in size from 290-841 mm TL (young-of-year and juveniles). Prior to and during the second blasting season (November 15, 2016-March 15, 2017), 391 Atlantic sturgeon were captured in the blasting area and relocated upriver. Prior to and during the third season, 2,506 Atlantic sturgeon were captured with the majority being young-of-year and juvenile age classes. See a model distribution in Figure 8.

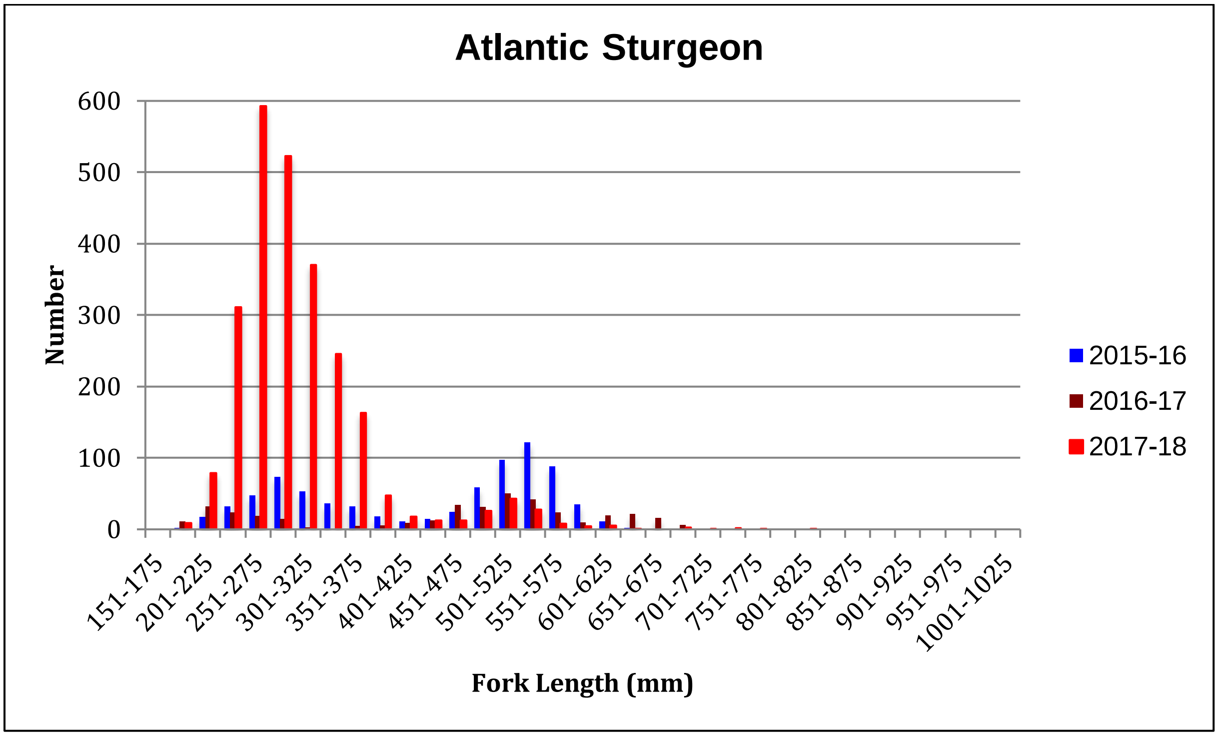

Figure 9. Length – Frequency Distribution of Atlantic Sturgeon Collected During Relocation Trawling, December 2015 – February 2018 (provided by Hal Brundage, 2018)

The Delaware Estuary is known to be used by 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). Breece *et al.* (2016) reported subadults using the Bay between April and June.

Brundage and O'Herron (in Calvo *et al.* (2010)) tagged 26 juvenile Atlantic sturgeon, including six young of the year (YOY). For non YOY fish, most detections occurred in the lower tidal Delaware River from the middle Liston Range (RKM 70) to Tinicum Island (RKM 141). For non

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

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

Following up on that study, between April and May of 2009-2012, a total of 195 adult Atlantic sturgeon were implanted with acoustic transmitters to track movements toward spawning areas in relation to salt front locations (Breece *et al.* 2013). The Delaware River study area ranged from the opening of the Chesapeake and Delaware Canal (RKM 94) to the head of tide in Trenton, NJ (RKM 210). Atlantic sturgeon inhabited areas of the river ± 30 km from the estimated salt front 84 percent of the time. Spawning condition adults occupied the river for 7-70 days from April-July, where they traveled as far upstream as Roebling, NJ (RKM 201) and displayed a preference for substrates consisting of mixed and uniform-grained reworking material. During the periods of the study when adult Atlantic sturgeon occupied the river, the average location of the salt front ranged from RKM 92 (2011) to RKM 112 (2009 and 2012). The model results suggested that Atlantic sturgeon occupy the region from New Castle, DE (RKM 99) to Tinicum Island, PA (RKM 137), with higher concentrations near Claymont, DE (RKM 125) and Chester, PA (RKM 130). The area between RKM 125 and 130 contains coarse grained and nondepositional bedrock habitat suitable for spawning (Breece *et al.* 2013).

Breece *et al.* (2013) argues that sea level rise, in conjunction with channel deepening efforts, may shift the average location of the salt front upstream, compressing the available habitat for spawning. They also state that movement of the salt front may increase sedimentation rates over current spawning habitat and concentrate Atlantic sturgeon in areas of the river with the highest volume of vessel traffic.

There has been some research to indicate that there may be a fall spawning run of adult Atlantic sturgeon in the Delaware River, as seen further south in the James River (Balazik *et al.* 2012a). Fox *et al.* (2015) observed several tagged individuals (sexes were male, female, and unknown) that entered the river in late spring and occupied suitable spawning habitats into the fall months. At this time, more research is needed to confirm whether or not independent run of fall spawning Atlantic sturgeon is occurring in the Delaware River.

As noted above, based on mixed-stock analysis (see Damon-Randall *et al.* 2013), we have determined that Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: Gulf of Maine 7 percent; NYB 58 percent; Chesapeake Bay 18 percent; South Atlantic 17 percent; and Carolina 0.5 percent. In the action area, any eggs, larvae, or young of the year (juveniles) would only originate from the Delaware River/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. 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.

5.4.3.1 Expected Seasonal Distribution of Atlantic Sturgeon from Philadelphia to the Sea (Reaches E, D, C, B, A, AA)

The discussion below summarizes the expected seasonal distribution of Atlantic sturgeon in the river reaches (see Table 1). Atlantic sturgeon are well distributed throughout the Delaware River and Bay and could be present year round in all of the river reaches. Because of low tolerance to salinity, early life stages (early stage juveniles, young-of-year, post yolk-sac larvae, yolk-sac larvae and eggs) are restricted to waters above the salt line, which moves seasonally (the median monthly salt front ranges from RKM 107.8 to RKM 122.3 (DRBC 2017)). Spawning, eggs, and yolk-sac larvae may occur within reaches of the river discussed below. Maintenance dredging will only remove shoaled areas of primarily soft substrates (silts) along with some sand, gravel, and small cobbles along the edges of shoals. The areas subject to shoaling are dynamic areas that feature unstable sediments that move easily along the riverbed to create shoals. The shoals are also navigational hazards for deep draft vessel traffic, which is why maintenance dredging is required. Therefore, these shoals occur in close proximity to deep draft vessel keels and propellers (see discussion in Section 5.3.2) which have as little as two feet of clearance from the channel bottom, and create daily disturbance and sedimentation from prop wash and turbidity plumes. While these primarily soft substrate shoals may have some gravel and small cobbles that could theoretically be used for spawning, given the dynamic nature of these areas, and that the substrate is often shifting and becoming covered with sediments from upstream transport and vessel traffic, the baseline conditions of this habitat for spawning and refuge, growth and development of early life stages of Atlantic sturgeon is very low and we do not expect that adults would select these areas for spawning or that these areas would typically be used for the settlement of eggs or by larvae for refuge.

Reach E includes RKM 8-66. Based on the best available information, including the high salinity levels in this reach, the presence of adult, subadult, and late-stage juvenile Atlantic sturgeon is possible year round. However, based on recent relocation trawling, salinity tolerant (older) juveniles likely overwinter closer to the salt front and the blasting area (ERC 2017). Early life stages will not be present in Reach E due to salinity levels in this reach.

Reach D includes RKM 66-89 and includes the area near Artificial Island. Based on the best available information, including the high salinity levels in this reach, the presence of adult, subadult, and late-stage juvenile Atlantic sturgeon is possible year round. Adults and subadults are most likely to be present from April to November, as the spend winter months in the lower estuary/bay, or other ocean aggregation areas.

Reach C encompasses the area from RKM 89-107.8 and includes the New Castle range. This area also includes the outlet of the Chesapeake-Delaware canal. Telemetered subadult Atlantic sturgeon have been tracked in the Chesapeake and Delaware Canal, with some passing completely through the canal (Simpson 2008). Based on the best available information, including the high salinity levels in this reach, the presence of adult, subadult, and late-stage juvenile Atlantic sturgeon is possible year round. Adults and subadults are most likely to be present from April to November, as they spend winter months in the lower estuary/bay, or other ocean aggregation areas. While the salt front does seasonally dip into Reach C, we generally expect young-of-year and post yolk-sac larvae (May through September) to remain upstream up Reach C. Based on Atlantic sturgeon spawning studies, we do not expect spawning or eggs and yolk-sac larvae to occur in Reach C.

Reach B (RKM 108-136.8) encompasses the Cherry Island Flats, Marcus Hook, Eddystone, Chester, and Tinicum areas. All life stages of Atlantic sturgeon could be present in Reach B. Adults and subadults are most likely to be present from April to November, as they spend winter months in the lower estuary/bay, or other ocean aggregation areas. Juveniles and young-of-year could be present throughout Reach B year-round (young-of-year would stay above the salt front). As discussed above, based on telemetered movements of spawning adults, spawning occurs from April through July, from RKM 125-212. Therefore, eggs and yolk-sac larvae could be present in appropriate spawning habitat from RKM 125 to the upper part of Reach B from April through August (if spawning were to occur near the end July, an additional 30 days accommodates the time needed for hatching and the yolk-sac larval stage). Post-yolk sac larvae could be present throughout Reach B from May through September (depending on the location of the salt front).

Similarly, Reaches A (RKM 137-156.1) and AA (RKM 156.3-164.2) may host all life stages of Atlantic sturgeon. Adults and subadults are most likely to be present from April to November, as they spend winter months in the lower estuary/bay, or other ocean aggregation areas. Juveniles and young-of-year could be present throughout Reaches A and AA year-round. As discussed above, based on telemetered movements of spawning adults, spawning occurs from April through July, from RKM 125-212. Therefore, eggs and yolk-sac larvae could be present in appropriate spawning habitat from April through August. Post-yolk sac larvae could be present throughout from May through September.

5.4.3.2 Expected Seasonal Distribution of Atlantic Sturgeon from Philadelphia to Trenton (Reaches A-B, B-C, C-D)

Reach A-B (RKM 176.9-204.2) and B-C (RKM 207.1-212.5) may contain all life stages of

Atlantic sturgeon. Adults and subadults are most likely to be present from April to November. Eggs and yolk-sac larvae could be present in appropriate spawning habitat (RKM 125-212) from April through August. Post-yolk sac larvae could be present throughout from May through September.

While possible, as there is no obstruction preventing their passage, it is unlikely that Atlantic sturgeon will be present in Reach C-D (RKM 212.5-214.5), as this is above the fall line and further upstream than nearly all sightings/trackings of Atlantic sturgeon.

5.4.4 Delaware River Critical Habitat Unit

As noted in section 4.13, the action area considered in this Opinion extends from RKM 5 (measured with the mouth of the Bay as RKM 0) to RKM 214.5. The Delaware River critical habitat unit is the waters of the Delaware River extending from the crossing of the Trenton-Morrisville Route 1 Toll Bridge downstream to where the river discharges into Delaware Bay. The action area contains all four PBFs.

The Delaware River Basin Commission (DRBC) defines the salt front as the area in the river where the water registers 250 milligram per liter (0.25 ppt) chloride concentration. The salt front is dynamic and its location fluctuates depending on several variables, namely the tidal inflows and streamflows, as well as scheduled water releases from five reservoirs used to push back the location of the salt front. DRBC reports the median location of the salt front to be from RKM 107.8 to RKM 122.3 (DRBC 2017). The border between PBF 1 and PBF 2 is where salinity is 0.5 ppt. Because salinity shifts daily, seasonally and annually, it is not possible to identify exactly where the break between PBF 1 and PBF 2 will be at any given time. However, we can use available salinity information to identify the general reaches where salinity is typically at 0.5 ppt or below.

5.4.4.1 PBF 1

Hard bottom substrate in low salinity waters suitable for the settlement of fertilized eggs, refuge, growth, and development of early life stages (i.e., PBF 1), can be found in the reaches of the river upstream of the salt front.

DRBC (2017) identifies RKM 107.8 as the lower part of the median range for the salt front (defined as 0.25 ppt); the historic salt front location is reported as approximately RKM 92. You have defined the oligohaline zone of the action area (i.e., the area that on average has salinity of 0.5 ppt or less) as the area between Marcus Hook and Trenton. However, you also note that 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 or range to move upstream or downstream by as much as 10 miles (~16 RKM) in a day due to semi-diurnal tides, and by more than 20 miles (~32 RKM) over periods ranging from a day to weeks or months due to storm and seasonal effects on freshwater inflows (USACE 2009b). Given the dynamic nature of salinity near the salt front, the availability of data on salinity levels of 0.25 ppt and not 0.5 ppt and the very small area where there would be a difference in salinity between 0.25 and 0.5 ppt, it is reasonable to use the furthest downstream extent of the median range of the location of the salt front (0.25 ppt) as a proxy for the downstream border of PBF 1 in the Delaware River. Therefore, we consider the area upstream of RKM 107.8 to have salinity levels consistent with the requirements of PBF 1. This stretch of river corresponds to Philadelphia to the Sea Reaches B (RKM 108-136.8), A (RKM 137-156.1), and AA (RKM 156.3-164.2), all of the Philadelphia to Trenton project, and the Marcus Hook Range Light project.

While, to date, eggs and larvae of Atlantic sturgeon have not been collected in the Delaware River, as noted in previous sections, tracking of adult Atlantic sturgeon combined with habitat (i.e., substrate type and salinity) information indicates where in the Delaware River spawning, and subsequently, early life stages are likely to occur. The presence of young of the year Atlantic sturgeon provides further evidence (Calvo *et al.* 2010, ERC 2016, 2017, 2018, Fisher 2009) that successful spawning and rearing occurs in the river and provides further insight on the location of spawning. Based on tagging and tracking studies, we know that Atlantic sturgeon spawning may occur upstream of the salt front over hard bottom substrate between Claymont, DE/Marcus Hook, PA (Marcus Hook Bar), approximately RKM 125, and the fall line at Trenton, NJ, approximately RKM 212 (Breece *et al.* 2013, Simpson 2008). Within that range, DiJohnson *et al.* (2015) provided evidence for suitable spawning habitat made of outcrops of bedrock and non-depositional, mixed grained material (i.e., hard but not stationary), occurring both within the navigation channel and along the northern edge of the channel near the Eddystone Range (~RKM 133-138).

Some areas have repeatedly shown up in tracking studies of spawning condition adults as areas of suspected spawning activity (e.g., the Marcus Hook Bar, Tinicum, and Eddystone Ranges in Reach B, ~RKM 125-138). These areas include relatively sheltered interstitial spaces amongst bedrock outcrops, boulders, and large cobble along the edges or outside of the navigation channel. The fact that these areas have maintained exposed outcrops of bedrock, boulders, and cobbles demonstrates that they are in locations where the current and sediment transport keep them clear of soft substrate deposits; these are also areas where substrate mobility is low and substrate is consistent over time (i.e., not subject to shoaling). The repeated detection of tagged adults in these areas (particularly RKM 125-138) indicates that these are likely areas of high quality spawning habitat that are regularly selected by adult Atlantic sturgeon.

In order for hard bottom substrate to be suitable for the settlement of fertilized eggs, refuge, growth, and development of early life stages, it must have interstitial spaces where eggs and/or larvae can settle or hide. In the Delaware River, suitable hard bottom substrate is expected to consist of areas with outcrops of bedrock, boulders, cobble, rock or gravel. One of the factors that affects the quality of potential spawning habitat is the degree to which it is impacted by turbidity and suspended sediment that may intermittently or continuously settle on top of the hard substrate. During spawning or rearing season, deposition of sediment on top of hard substrate can diminish the ability of eggs to adhere to the substrate or result in the burial, entrapment and/or suffocation of early life stages. Another factor that affects the quality of potential spawning habitat is how dynamic or mobile the sediments are in a particular area; even if an area is not subject being covered by soft sediments, if the hard substrate in the area is highly mobile (i.e., there is a lot of movement or shifting of gravels or cobbles) this may be lower quality spawning habitat, as there would be a higher potential for early life stages to be dislodged, buried or destroyed. These two factors are likely why spawning typically occurs in waters within a certain velocity range - sufficient water velocities to keep the substrate clear of soft sediment deposits but not so high as there would be frequent shifting or mobility of smaller, hard substrates.

You have indicated that the vast majority of maintenance dredging of shoals will remove soft substrates (see Table 2). Occasionally, you encounter gravel and small cobbles in small edge shoaling areas (e.g., near Eddystone and Philadelphia Harbor) that require dredging on a less frequent basis (i.e., once every few years). When the shoals get to a point when they are coming in close enough contact (if not direct contact) with the keels and propellers of boats, you determine that they need to be dredged. These shoals are characterized by their mobile, dynamic substrates (which results in the formation of these shoals). These shoaled areas may also be more vulnerable to disturbances resulting from natural (i.e., storms, flood events) and anthropogenic (i.e., prop wash) factors that make the shoals of a lower quality for spawning and rearing. While these primarily soft-substrate shoals may have some gravel and small cobbles that could theoretically be used for spawning, given the dynamic nature of these areas, and that the substrate is often shifting and becoming covered with sediments from upstream transport and vessel traffic, the baseline conditions of this habitat for spawning and refuge, growth and development of early life stages of Atlantic sturgeon is very low and we do not expect that adults would select these areas for spawning or that these areas would typically be used for the settlement of eggs or by larvae for refuge. As such, while these edge shoals may contain hard substrates in low salinity waters, they do not function to support the settlement of fertilized eggs or the refuge, growth or development of early life stages and are therefore not considered to be PBF 1.

As described in Section 5.3.2, the Federal navigation channel is subject to a daily disturbance regime from deep draft commercial vessels operating throughout the reaches where PBF 1 is present, up to the Fairless Terminal which is approximately 8 RKM below Trenton, New Jersey. The use of the navigation channel by large vessels is expected to result in effects to some areas of hard substrate; these effects are a result of direct disturbance of gravel/rock that may be partially disturbed or displaced by prop wash and where soft sediments are disturbed/displaced and settle out on top of hard bottom substrates (in areas where currents are such that the substrate is not quickly cleared). Other activities that impact hard substrates in low salinity waters are maintenance dredging activities (such as those considered in this Opinion) and other construction activities that result in the displacement or removal of hard substrates or result in the displacement of soft substrates that can settle on hard bottom areas. Effects of climate change are considered below in Section 6.0.

5.4.4.2 PBF 2

In the Delaware River, aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites to support juvenile foraging and physiological development (i.e., PBF 2) occurs from approximately RKM 78 (where the final rule describes the mouth of the river) to approximately RKM 107.8, or the downstream median range of the salt front. As described above, salinity levels in the river are dynamic, and the salt front is defined by a lower concentration (0.25 ppt) than the lower level of PBF 2 (0.5 ppt), but 107.8 is a reasonable approximation given the lack of real time data. As such, the portion of Reach D (RKM 66.1-88.5) above RKM 78 and Reach C (RKM 88.7-107.8) overlap with the area where PBF 2 occurs. We estimate the total area of critical habitat (bank to bank in the mainstem of the river between RKM 78 and 107.8) to be 29,430 acres. We used DNREC's shapefile data "Delaware Bay Upper Shelf Bottom Sediments 2008-2010" (Metadata created 2015) to come up with a ratio of soft bottom substrate to hard bottom substrate in the areas they surveyed between RKM 78-107.8: 78 percent unconsolidated sediments; 22 percent reef/hard bottom. Without additional information, we assume all unconsolidated sediments defined by DNREC may consist of soft substrates (e.g., sand, mud). We made the assumption that the data they collected was a representative sample of the substrate in the bank to bank area of critical habitat between RKM 78-107.8, extrapolated DNREC's findings to the 29,430 acre area of critical habitat in this reach, and estimate that 22,980 acres potentially meet the criteria for PBF 2 within critical habitat in the action area.

Captured sturgeon and subsequent tracking studies have provided evidence for the use of soft substrate habitat in the Delaware River with the salinity gradient matching the criteria for PBF 2. Detections of tagged juvenile Atlantic sturgeon, have been documented in the lower tidal Delaware River, especially between the middle Liston Range (RKM 70) to Tinicum Island (RKM 141)(Calvo *et al.* 2010). Juveniles tracked in this study ranged in size. Older, larger juveniles (average 716mm, range 505-947mm) moved towards the Bay but were not detected below Liston Range. The smaller juveniles averaged 524 mm (range 485-566 mm).

Based on the best available information on the distribution of juveniles in the Delaware River, we generally expect that juveniles will use the transitional salinity zone year round. Foraging is expected to occur over soft substrates that support the benthic invertebrates that juvenile Atlantic sturgeon eat. Juveniles are thought to forage year-round with foraging lightest during the winter. The most active foraging in these areas likely occurs in the spring to fall months. Later in the fall, larger, late-stage juveniles likely move out of this transitional zone into more saline waters in the lower Delaware River estuary (without leaving the estuary altogether, as that would indicate a transition to the subadult life stage), while the younger juveniles remain and either continue foraging, or move upstream in winter aggregation areas, such as those documented near Marcus Hook (ERC 2016, 2017, 2018).

Activities that have impacted and will continue to impact PBF 2 include those that impact salinity and those that result in the loss or disturbance of soft sediment within the transitional salinity zone. These include activities (e.g., disturbance of soft substrate by deep draft vessels, construction) that result in sediment disturbance and subsequent sediment deposition that buries prey species (where that deposited sediment is not immediately swept away with the current), direct removal or displacement of soft bottom substrate (e.g., dredging, construction), activities that result in the contamination or degradation of habitat reducing or eliminating populations of benthic invertebrates, and activities that influence the salinity gradient (e.g., climate change, deepening of the river channel).

Soft substrate within the navigation channel of Reaches D and C may be disturbed by large, deep draft, commercial vessels. This may result in the burial or displacement of some benthic resources, particularly those that occur on or near the surface and those that are less mobile. This may result in a reduction in the availability of benthic resources in some areas. Conversely, in some areas, the disturbance of the bottom by vessels may actually expose benthic invertebrates and attract foraging juvenile sturgeon. The extent to which the disturbance of soft sediments by vessels passing through these areas is unknown and it is unclear how these impacts are different from the impacts of natural factors such as flood and storm events. The composition of benthic invertebrates in frequently disturbed areas may be different than areas that are disturbed less frequently as, for example, some species of worms thrive in frequently disturbed areas, while other species may be less able to thrive in a frequently disturbed area.

If shoaling occurs within the channel, these shoals are subsequently removed when they become obstacles for navigation. Dredging results in the removal of sediment to restore navigational depths also removes many of the inhabiting benthic invertebrates. While recolonization may begin quickly after dredging is completed, it may take up to two years for those areas to be fully recolonized by benthic invertebrates.

As noted above, we estimate that 22,980 acres potentially meet the criteria for PBF 2 within critical habitat in the action area. The navigation channel in this same reach of the river (RKM 78-107.8) encompasses an area of approximately 1,954 acres. Therefore, up to 8.5 percent of the area where we expect PBF 2 to occur is subject to vessel disturbance (assuming all habitat in the navigation channel in this reach meets the criteria for PBF 2). Dredging to remove shoals occurs in a smaller percentage of that total area within the channel (we consider effects of maintenance dredging to PBF 2 in Section 7.9.2).

As described in Section 5.3.1, water pollution and contamination have historically been, and continue to be, an issue in the Delaware River, despite significant progress in limiting pollution and improving water quality in the past few decades. 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 benthic fauna consumed by foraging juvenile sturgeon in the transitional salinity zone. We consider the impacts of climate change in Section 6.0.

5.4.4.3 <u>PBF 3</u>

Water of appropriate depth and absent physical barriers to passage between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of subadults or spawning condition adults, are present throughout the extent of critical habitat designated in the Delaware River. Water depths in the main river channels is also deep enough (*e.g.,* at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. Therefore, PBF 3 overlaps with Reaches D, C, B, A, AA, the entire Philadelphia to Trenton project, and the Marcus Hook Range Light project. Physical barriers that may impede sturgeon passage include (but are not limited to) locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc. Sturgeon need to be able to make unimpeded movements up and downstream at all lifestages. Adults must be able to stage before spawning and then move to and from the river mouth to spawning sites; subadults need to be able to enter the river for foraging opportunities; and juveniles must be able to move between appropriate salinity zones, foraging areas, and overwintering sites.

The Delaware River is the longest un-dammed river in the United States east of the Mississippi, extending over 300 miles from the confluence of its East and West branches at Hancock, N.Y. to the mouth of the Delaware Bay (DRBC 2017). While there are nearly always some impediments to sturgeon movements (i.e., piers, pilings, etc. that sturgeon move around as they move up and downstream within the river) there are no permanent barriers to movement. In addition to navigating around existing structures, sturgeon movements are also impacted by gear set in the river, vessel traffic, and in-water stressors from ongoing construction projects (e.g., turbidity from dredging, sound pressure waves from pile driving, etc.). Studies have shown that even in close proximity to active dredging equipment, sturgeon pass through the area, while showing little to no sign of disturbance (Reine *et al.* 2014; Moser and Ross 1993; Cameron 2012). Additionally, while water quality has significantly improved in the Delaware River and seasonal anoxic areas are now rare, the movement of Atlantic sturgeon in the river is also impacted by areas with poor water quality.

5.4.4.4 PBF 4

The area with PBF 4 (water between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that combined support spawning, survival, and larval, juvenile, and subadult development and recruitment), may be present throughout the extent of critical habitat designated in the Delaware River (depending on the life stage); therefore, PBF 4 overlaps with Reaches D, C, B, A, AA, the entire Philadelphia to Trenton project, and the Marcus Hook Range Light project.

Water quality factors of temperature, salinity and dissolved oxygen are interrelated environmental variables, and in a river system such as the Delaware, are constantly changing from influences of the tide, weather, season, etc. Dissolved oxygen concentrations in water can fluctuate given a number of factors including water temperature (e.g., cold water holds more oxygen than warm water) and salinity (e.g., the amount of oxygen that can dissolve in water decreases as salinity increases). This means that, for example, the dissolved oxygen levels that support growth and development will be different at different combinations of water temperature and salinity. Similarly, the dissolved oxygen levels that we would expect Atlantic sturgeon to avoid would also vary depending on the particular water temperature, salinity, and life stage. As dissolved oxygen tolerance changes with age, the conditions that support growth and development and likewise, the dissolved oxygen levels that would be avoided, change (82 FR 39160; August 17, 2017).

On top of natural fluctuations in water quality, a number of human activities directly impact the temperature, salinity, and oxygen values within the Delaware River (also see discussion in Section 5.3.1). Water pollution, whether it be urban and rural runoff, combined sewer overflows (CSOs), accidental spills (e.g., Athos spill covered in Section 5.1.3), or thermal plumes from nuclear generating stations (e.g., Salem and Hope Creek, Section 5.1.2) impact the water quality parameters in PBF 4. Construction activity also impacts water quality. Turbidity from dredging or vessel activity that impacts soft substrate may decrease levels of light and impact temperature. Dredging has the potential to increase water depths and cause cooling at the bottom of the water column (i.e., deeper water receives less light). Climate change, the effects of which are discussed in Section 6.0, will likely lead to an upstream shift in the salt front from rising sea levels. Therefore, the lower salinity levels needed for spawning and rearing of early life stages (eggs, larvae, young of year) will be found further upriver. With no upstream dams limiting their access to upstream areas, the presence of hard bottom substrate up to and past the fall line and the documented occurrence of Atlantic sturgeon above the fall line, Atlantic sturgeon are expected to be able to shift upstream as necessary to respond to climate change related changes to salinity in the Delaware River.

Overall, water quality in the Delaware River has improved dramatically since the mid-20th century. In the late 1800s into the mid-1900s, water pollution still caused much of the lower Delaware River to be anoxic in the summer and fall months (DRBC Task Force 1979 and Albert 1988 in Moberg and DeLucia 2016), which created a barrier for diadromous fish passage. Two major causes of the turnaround in water quality were the passage of the Federal Water Pollution Control Act in 1948 (later amended in 1972 and more commonly called the Clean Water Act) and the creation of the DRBC, a federal-interstate agency created in October 1961. Despite improvements, Moberg and DeLucia (2016) concluded that dissolved oxygen levels between 2005 and 2014 were still frequently in ranges identified as impaired (below 5.0 mg/L) or lethal (4.0 mg/L) for early life stages of Atlantic sturgeon.

At this time, while water quality conditions, particularly levels of DO, may be limiting the successful recruitment of early life stage Atlantic sturgeon, the capture of young of the year Atlantic sturgeon provides evidence that the current status of PBF 4 enables all essential Atlantic sturgeon life stages and behaviors to occur, with varying levels of success.

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 2068). 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 (see Sections 6.3 and 6.4 below).

6.1 Global Climate Change and Ocean Acidification

In addition to the information on climate change presented in the *Status of the Species* section for sea turtles and sturgeon, the discussion below presents further background information on global climate change as well as past and projected effects of global climate change throughout the range of the ESA-listed species considered in this Opinion. Below is the available information on projected effects of climate change in the action area and how listed sea turtles and sturgeon may be affected by those projected environmental changes. The effects are summarized on the time span of the proposed action, for which we can realistically analyze impacts, yet are discussed and considered for longer time periods when feasible.

In its Fifth Assessment Report (AR5) from 2013, the Intergovernmental Panel on Climate Change (IPCC) stated that the globally averaged combined land and ocean surface temperature data has shown a warming of 0.85°C (likely range: 0.65° to 1.06°C) over the period of 1880-2012. Similarly, the total increase between the average of the 1850-1900 period and the 2003-2012 period is 0.78°C (likely range: 0.72° to 0.85°C). On a global scale, ocean warming has been largest near the surface, with the upper 75 meters of the world's oceans having warmed by 0.11°C (likely range: 0.09° to 0.13°C) per decade over the period of 1971-2010 (IPCC 2013). In regards to resultant sea level rise, it is very likely that the mean rate of global averaged sea level rise was 1.7 millimeters/year (likely range: 1.5 to 1.9 millimeters/year) between 1901 and 2010, 2.0 millimeters/year (likely range: 1.7 to 2.3 millimeters/year) between 1971 and 2010, and 3.2 millimeters/year (likely range: 2.8 to 3.6 millimeters/year) between 1993 and 2010.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next several decades. The global mean surface temperature change for the period 2016-2035 relative to 1986-2005 will likely be in the range of 0.3° to 0.7°C (medium confidence). This assessment is based on multiple lines of evidence and assumes there will be no major volcanic eruptions or secular changes in total solar irradiance. Relative to natural internal variability, near-term increases in seasonal mean and annual mean temperatures are expected to be larger in the tropics and subtropics than in mid- and high latitudes (high confidence). 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 also resulted in increased river discharge and glacial and sea-ice melting (Greene *et al.* 2008). The strongest ocean warming is projected for the surface in tropical and Northern Hemisphere subtropical regions. At greater depths, the warming will be most pronounced in the Southern Ocean (high confidence). Best estimates of ocean warming in the top 100 meters are about 0.6° to 2.0°C, and about 0.3° to 0.6°C at a depth of about 1,000 meters by the end of the 21st century (IPCC 2013).

Under Representative Concentration Pathway (RCP) 8.5, the climate change scenario where emission levels continue to rise throughout the 21st century, the projected change in global mean surface air temperature and global mean sea level rise for the mid- and late 21st century relative to the reference period of 1986-2005 is as follows. Global average surface temperatures are likely to be 2.0°C higher (likely range: 1.4° to 2.6°C) from 2046-2065 and 3.7°C higher (likely range: 2.6° to 4.8°C) from 2081-2100. Global mean sea levels are likely to be 0.30 meters higher (likely range: 0.22 to 0.38 meters) from 2046-2065 and 0.63 meters higher (likely range: 0.45 to 0.82 meters) from 2081-2100, with a rate of sea level rise during 2081-2100 of 8 to 16 millimeters/year (medium confidence). There is uncertainty about the magnitude of global sea level rise, projected to rise .30 to 1.22 meters by 2100, as it is primarily dependent on the dynamics of ice sheet melting (Melillo *et al.* 2014),

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 2007a). 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 2007b). The NAO impacts climate variability throughout the Northern Hemisphere (IPCC 2007b). Data from the 1960s through the 2000s showed that the NAO index increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2007b). This warming extends over 1,000 meters deep and is deeper than anywhere in the world's oceans and is particularly evident under the Gulf Stream/North Atlantic Current system. 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 2007b). There is evidence that the NADW has already freshened significantly (IPCC 2007). 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 entire world (Greene *et al.* 2008).

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 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 2007). These trends have been most apparent over the past few decades, although this may also be due to increased research. Information on future impacts of climate change in the action area is discussed below.

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 action area, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Additional information on potential effects of climate change specific to the action area is discussed below. Warming is very likely to continue in the U.S. over the next 50 years regardless of reduction in greenhouse gases, 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 50 years, and it is possible that they 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 2007b).

Expected consequences of climate change for river systems 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 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. Surface water resources along the U.S. Atlantic coast 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 will experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2^{o}C per decade; and 3) a rise in sea level (NAST 2000). Sea level is expected to continue rising; during the 20th century global sea level has increased 15 to 20 centimeters. It is also important to note that ocean temperature in the U.S. Northeast Shelf and surrounding Northwest Atlantic waters have warmed faster than the global average over the last decade (Pershing *et al.* 2015). New projections for the U.S. Northeast Shelf and Northwest Atlantic Ocean suggest that this region will warm two to three times faster than the global average and thus existing projections from the IPCC may be too conservative (Saba *et al.* 2015). Hare *et al.* (2016b) provides a literature summary of other aspects of the climate system that is changing on the U.S. Northeast Shelf including a high rate of sea-level rise, as well as increases in annual precipitation and river flow, magnitude of extreme precipitation events, magnitude and frequency of floods, and dissolved CO_2.

6.2 Potential 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 and Dobshinsky 2008) and the availability of water for human use (e.g., e.g., e.g., e.g., Ayers *et al.* 1993). Documents prepared by USACE for the deepening project have considered climate change (USACE 2009c, 2011b), 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 percent increase in precipitation predicted as well as an increase in the frequency of short term drought, a decline in the number of frost days, and an increase in growing season length predicted by 2100.

The report notes that the Mid-Atlantic States are anticipated to experience sea level rise greater than the global average (Karl *et al.* 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 (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 (Kreeger *et al.* 2010). Rates of subsidence and accretion vary in different areas around the Delaware Estuary, but the greatest loss of shoreline habitat is expected to occur where subsidence is naturally high in areas that cannot accrete more sediment to compensate for elevation loss plus absolute sea-level rise. The net increase in sea-level compared to the change in land elevation is referred to as the rate of relative sea-level rise (RSRL). Kreeger *et al.* (2010) 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 has been predicted to result in a northward movement of the salt wedge in the Delaware River (Collier 2011). Currently, the normal average location of the salt wedge is at approximately RKM 114 (median monthly salt front ranges from RKM 107.8 to RKM 122.3 (DRBC 2017)). Collier predicts that without mitigation (e.g., increased release of flows into downstream areas of the river), at high tide in the peak of the summer during extreme drought conditions, the salt line could be as far upstream as RKM 183 in 2050 and RKM 188 in 2100. The farthest north the salt line has historically been documented was approximately RKM 166 during a period of severe drought in 1965; thus, she predicts that over time, during certain extreme conditions, the salt line could shift up to 17 km further upstream by 2050 and 22 km further upstream by 2100.

Ross *et al.* (2015) sought to determine which variables have an influence on the salinity of the Delaware Estuary. Many factors have an influence on salinity and water quality in an estuary including stream flow, oceans salinity, sea level and wind stress (Ross *et al.* 2015). By creating statistical models relying on long-term (1950-present) data collected by USGS and the Haskin Shellfish Research Laboratory, the authors found that after accounting for the influence of streamflow and seasonal effects, several locations in the estuary show significant upward trends in salinity. These trends are positively correlated with sea level rise, and salinity appears to be rising 2.5-4.4 PPT per meter of sea level rise. Ross *et al.* (2015) noted that dredging can also impact salinity, but suggested that dredging at Chester (i.e., increased depth to 45 ft) has not influenced long-term salinity trends as the statistical models did not detect a significant salinity trend in the area.

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. Ross *et al.* (2015) found that regardless of any change in streamflow, future sea-level rise will cause salinity to increase.

Water temperature in the Delaware River varies seasonally. 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). Kaushal *et al.* (2010) found that water temperatures are increasing in many streams and rivers throughout the US with the Delaware River near Chester, Pennsylvania, having the most rapid rate of increase (of 0.077°C yr^{-1}; 1965-2007). There was also a significant increase ($P < 0.05$) at the Ben Franklin Bridge (near Philadelphia, Pennsylvania; 1965-2007; Kaushal *et al.*, 2010). However, not every site along the Delaware River showed significant increases, and those sites with the most rapid increase rates were located in downstream urban areas (Kaushal *et al.* 2010). Moberg and DeLucia (2016) compiled recent literature and information including USGS data from 2005-2014 showing higher river temperatures (27 to 29°C) in the Delaware in recent years.

Information from a recent effort to develop high-resolution future projections of air temperature and surface water temperature for the Chesapeake Bay out to 2100 can be used to provide insights for the Delaware Bay (Muhling *et al.* 2017). Muhling *et al.* (2017) also projected salinity, but these conclusions would likely be specific to just the Chesapeake Bay based on the complexities noted above (e.g., Ross *et al.*, 2015). Air temperature has been used for coastal and freshwater water temperature trends (Tommasi *et al.* 2015) so may be more easily applied to a regional scale, including the Delaware River. Projected annual air temperature increase between

1979-2008 vs. 2071-2100 indicates that future warming between the Chesapeake and Delaware and their major watersheds will be reasonably similar (see air temperature including RCP 8.5 and all models at NOAA's Climate Change Web Portal; https://www.esrl.noaa.gov/psd/ipcc/cmip5/). Potential future surface water temperature increases in the Chesapeake Bay of 2.5-5.5°C by the end of the century were projected over late 20th century values, with the wide range of values primarily a result of differences in the four global climate models (Muhling *et al.* 2017), and would probably be similar to the Delaware Bay. Muhling *et al.* (2017) noted that summer surface water temperatures may increase to between 27 and > 30°C depending on the climate model, which represents a moderate to potentially lethal change in conditions for species such as Atlantic sturgeon. Using data from Muhling *et al.* (2017) over the time period of the action (2017-2068), annual mean air temperatures at the Thomas Point buoy (latitude 38.9°N, longitude 76.4°W) may range from ~14.9 to 16.9°C, using projections from the coolest (MRI_CGCM-3) and warmest (GFDL-CM3) models, respectively, compared to a late 20th century mean of ~13.6°C. Annual mean surface water temperatures across the whole Chesapeake Bay were projected to range from ~16.5 to 18.3°C from the same two models over the same time period, compared to a late 20th century mean of ~15.4°C.

Expected consequences of climate change for river systems could be a decrease in the amount of dissolved oxygen in surface waters (Murdoch *et al.* 2000). Moberg and DeLucia (2016) compiled recent studies and information including USGS data showing a relationship between increasing temperature and decreasing DO in the Delaware River. For example, Moberg and DeLucia (2016) highlighted that DO levels < 4.0 mg/L occurred when temperatures were > 25°C and DO levels < 5.0 mg/L occurred when temperatures were > 23°C during observations in July and August 2005-2014.

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

Sea turtle species have persisted for millions of years and throughout this time have experienced wide variations in global climate conditions and have successfully adapted to these changes. As such, climate change at normal rates (thousands of years) is not thought to have historically been a problem for sea turtle species. As outlined in the Status of the Species sections above, sea turtles are most likely to be affected by climate change due to (1) changing air temperature and rainfall at nesting beaches, which in turn could impact nest success (hatching success and hatchling emergence rate) and sex ratios among hatchlings; (2) sea level rise, which could result in a reduction or shift in available nesting beach habitat and increased risk of nest inundation; (3) 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 (4) changes in water temperature, which could possibly lead to a northward shift in their range and changes in phenology (timing of nesting seasons, timing of migrations). Over the time period of this action 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, distribution, and recruitment 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.

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 Northeast. 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 12 eggs hatched, with eight hatchlings surviving. In December, seven of the hatchlings were released in Cape Hatteras, North Carolina. In September 2017, about 100 baby loggerheads successfully emerged from nests on the Maryland side of Assateague Island. 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. The projected increase in ocean temperature over the next fifty years is unlikely to allow for more successful rearing of sea turtle eggs in the action area. However, if increased nesting activity were to begin occurring, that would constitute new information that may require reinitiation of this Opinion.

6.4 Effects of Climate Change in the Action Area to Atlantic and shortnose sturgeon and the Delaware River Critical Habitat Unit

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on shortnose and Atlantic sturgeon. We have analyzed the available information, however, to consider likely impacts to sturgeon and their habitat in the action area. We consider here, likely effects of climate change during the period from now until 2068, the duration of the effects from the proposed project.

Water availability, either too much or too little, as a result of global climate change is expected to have an effect on the features essential to successful sturgeon spawning and recruitment of the offspring to the marine environment (for Atlantic sturgeon). The increased rainfall predicted by some models in some areas may increase runoff, scour spawning areas, and create flooding events that dislodge early life stages from the substrate where they refuge in the first weeks of life. High freshwater inputs during juvenile development can influence juveniles to move further downriver and, conversely, lower than normal freshwater inputs can influence juveniles to move further upriver potentially exposing the fish to threats they would not typically encounter. Increased number or duration of drought events (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 spawning season(s) may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all sturgeon life stages, including adults, may become susceptible to stranding or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues including effects to the combined interactions of dissolved oxygen, water temperature, and salinity. Elevated air temperatures can also impact dissolved oxygen levels in the water, particularly in areas of low water depth, low flow, and elevated water temperature. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems affecting dissolved oxygen and temperature.

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 (affecting Atlantic sturgeon critical habitat PBFs 1, 2, and 4). Upstream shifts in spawning or rearing habitat (PBF 1) 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 you indicates that this is unlikely to occur before 2040 but modeling conducted by Collier (2011) suggests that by 2100, some areas within the range where spawning is thought to occur (RKM 125-212), may be too salty and spawning would need to shift further north. Breece *et al.* (2013) used habitat modeling to consider where adult Atlantic sturgeon would be located under various scenarios including the location of the salt front due to changes in sea level rise in 2100 (i.e., occurring RKM 122-137 based on a 1986 EPA report for the Delaware Estuary) and under extreme historic drought (i.e., restricted to RKM 125, 130 and 153 based on drought conditions observed in the 1960's). Given the availability and location of spawning habitat in the river, it is unlikely that the salt front would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. Shortnose sturgeon spawning habitat (RKM 214-238) is approximately 90 km upstream of the current median range of the salt front (RKM 122). Atlantic sturgeon spawning habitat (RKM 125-212) is at greater risk from encroaching salt water, with some of the best potential spawning habitat at the downstream end of that range (i.e., Marcus Hook Bar area). However, without an upstream barrier to passage, and spawning habitat extending to Trenton, NJ, it is unlikely that salt front movement upstream would significantly limit spawning and nursery habitat. The available habitat for juvenile sturgeon of both sturgeon species could decrease over time; however, even if the salt front shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon. The areas in the Delaware River critical habitat unit containing PBF 2 (aquatic habitat with soft substrate and a gradual downstream salinity gradient of 0.5-30 ppt for juvenile foraging and physiological development) may also shift upstream, but would not necessarily be diminished in size or quality.

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. 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, Atlantic sturgeon may be excluded from some habitats. Additionally, temperature 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. 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.

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 difficult to predict how any change in water temperature or river flow will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift to earlier in the year. Moberg and DeLucia (2016) noted that low flow conditions influence the salt front location and available freshwater habits that are suitable for early life stages. DO concentrations between 2005 and 2014 were often in ranges identified as impaired or lethal for Atlantic sturgeon early life stages (Moberg and DeLucia 2016).

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 is 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 (Damon-Randall 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 (Jenkins *et al.* 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. Muhling *et al.* (in review) noted that the predicted increase in summer surface temperatures may increase to between 27 - 29 °C and > 30°C depending on the climate model, in the Chesapeake Bay which represents a moderate to potentially lethal change in conditions for species such as Atlantic sturgeon. It is possible that these values may be similar to the Delaware Bay (see above). 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 have ranged from 11-27°C from April – November, with temperatures lower than 11°C from December-March. As noted above, there are various studies looking at temperature in the Delaware Bay (Moberg and DeLucia 2016). Rising temperatures could meet or exceed 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, over time, sturgeon could 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. When we designated the Delaware River as critical habitat for the New York Bight DPS of Atlantic sturgeon, we did not extend any areas upstream because of anticipated impacts of climate change. Rather, we determined that the areas designated would accommodate any changes in distribution of the PBFs that may result from climate change.

The overall vulnerability of Atlantic sturgeon to climate change has been found to be very high (Hare *et al.* 2016a). Moberg and DeLucia (2016) recommended the following water quality standards to support successful recruitment of Atlantic sturgeon in the Delaware River: instantaneous DO ≥ 5.0 mg/L; temperature < 28°C; salinity < 0.5 ppt; and discharge > July Q85 (4,000 cfs @ Ben Franklin), when average daily DO < 5.5 mg/L. Our final rule for Atlantic sturgeon critical habitat (NMFS 2017) states that dissolved oxygen levels of 6.0 mg/L or greater likely supports juvenile rearing habitat, whereas DO less than 5.0 mg/L for longer than 30 days is less likely to support rearing when water temperature is greater than 25 °C. In temperatures greater than 26 °C, DO greater than 4.3 mg/L is needed to protect survival and growth. Temperatures of 13 to 26 °C likely to support spawning habitat.

More information for shortnose sturgeon in Delaware River and Bay, as well as additional information on Atlantic sturgeon are needed in order to better assess impacts from climate change.

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). This Opinion examines the likely effects (direct, indirect, and interrelated/interdependent) of the proposed action on shortnose sturgeon, five DPSs of Atlantic sturgeon, the Delaware River Unit of critical habitat designated for Atlantic sturgeon (NYB DPS), and sea turtles in the action area and their habitat within the context of the species status now and projected over the course of the action, the environmental baseline and cumulative effects. As explained in the "Description of the Action" section, the action under consideration in this Opinion includes:

- the ongoing dredging needed to deepen the channel which will be conducted until March 15, 2019 (or March 15, 2020 depending on funding),
- blasting to facilitate the deepening of the channel that will occur between December 1, 2018 to March 15, 2019 or December 2019 to March 15, 2020,
- associated clean-up mechanical dredging that will occur between July 1, 2019, and March 15, 2020 (or between July 1, 2020, and March 15, 2021 depending on funding),
- maintenance dredging of the 45-foot channel from Philadelphia to the Sea, and the Philadelphia to Trenton navigation channel through 2068,
- beneficial use of dredged material (Oakwood Beach Hurricane and Storm Damage Reduction Project and the DMU study), and
- the Marcus Hook Range Light project.

As explained in the "Description of the Proposed Action" section above, hydraulic cutterhead, hopper and mechanical dredges will be used for deepening and maintenance dredging activities. A final blasting and relocation trawling season will be required to complete deepening in Reach B. Refer to Table 1 in the "Description of the Proposed Action" section for a summary of the proposed activities 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 blasting and relocation trawling, dredging and disposal on water quality, including turbidity/suspended sediment, and effects of project vessel traffic. 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). Effects to Atlantic sturgeon critical habitat are considered in section 7.9 below.

7.1 Risk of Entrainment in Hopper Dredges

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

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

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

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

Industry and government hopper dredges are equipped with various power and pump configurations and may differ in hopper capacity with different dredging capabilities. An engineering analysis of the known hydraulic characteristics of the pump and pipeline system on the USACE hopper dredge “Essayons” (a 6,423 cy hopper dredge) indicates an operational flow rate of forty cubic feet per second with a flow velocity of eleven feet per second at the draghead port openings. The estimated force exerted on a one-foot diameter turtle (i.e. one-foot diameter disc shaped object) at the pump operational point in this system was estimated to be twenty-eight pounds of suction or drag force on the object at the port opening of the draghead.

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

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

The use of UXO and MEC screens prevents an object larger than 1.5 inches in diameter that is entrained by the suction at the intake of the draghead from being transported and discharged at the dredge material outlet into the hopper or at the cutterhead dredged material discharge point (e.g. on the beach during beach nourishment). Therefore, it reduces the likelihood of sea turtles or large sturgeon that are entrained in the suction at the draghead intake from being observed in the discharge as they would be impinged on the screen rather than transported through the dredge pipes. However, while the use of UXO screening poses challenges for monitoring interactions with listed species, its use is not expected to change the interaction rates. That is because while it may prevent turtles or sturgeon from entering the intake pipes (and thereby being transported through the system to the discharge end), it does not change the way the dredge operates or the suction power at the draghead intake. So, while it is unlikely for sea turtles or sturgeon to be sucked through the dredge plant (as this could be prevented by the small size of the intakes from the screening), the risk of an interaction (i.e. entrainment in suction current at the draghead and impingement on the screen) does not change. A sturgeon or turtle impinged on the draghead intake would be expected to be crushed by the dredge head such that it is injured or killed and/or, for sea turtles, drown.

7.1.1 Entrainment in Hopper Dredges – Sea Turtles

At the issuance of our 2017 opinion, you had estimated that the remaining deepening would remove a total of 1,300,000 cy from Reach E via hopper dredge, with disposal occurring on Artificial Island CDF and Buoy 10; you expected to complete deepening of Reach E by the end of December 2017. However, the dredging was completed on August 31, 2018 (Table 1). You estimate that maintenance of the 45-foot channel in Reach D will occur on a 3-year cycle (~17 events from now through 2068) and involve the removal of 1,000,000 cy of sand per cycle, which is inclusive of the material for periodic nourishment of Oakwood Beach (approximately 33,000 cy of sand every 8 years). A UXO screen will be used for the removal of material that will be used for beach nourishment. Exact scheduling is dependent on funding and availability of dredge equipment. You estimate that maintenance of the 45-foot channel in Reach E will occur on an annual basis (~50 events from now through 2068) and involve the removal of 400,000 cy of sand per cycle. The estimated volumes dredged from Reach E include initial and periodic beach nourishment of the DMU sites in Delaware (approximately 1,630,000 cy for the initial construction and 400,000 cy every six years) and in New Jersey (approximately 1,150,000 cy for the initial construction and 180,000 cy every six years). A hopper dredge may also be used for maintenance in other reaches of the river; however, no sea turtles occur upstream of Reach D so no sea turtles will be exposed to effects of hopper dredging carried out outside of Reach D or E.

7.1.1.1 Background Information on Entrainment of Sea Turtles in Hopper Dredges

As outlined above, sea turtles are likely to occur in Delaware Bay from May through mid-November each year with the largest numbers present from June through October of any year (Stetzar 2002). The majority of sea turtles in the Delaware Estuary are juvenile loggerheads; however, adult loggerheads, juvenile Kemp's ridley, adult and juvenile leatherback and adult green sea turtles have also been documented in the area. The Delaware Estuary is an important foraging area for sea turtles and an important developmental habitat for juvenile sea turtles, particularly loggerheads. The only dredging operations that are scheduled to occur in the geographic region of the action area where sea turtles are likely to occur are deepening and maintenance in Reaches D and E.

Entrainment is the direct uptake of aquatic organisms by the suction field generated at the draghead. Hydraulic dredges operate for prolonged periods underwater, with minimal disturbance, but generate continuous flow fields of suction forces while dredging. Loggerhead, Kemp's ridley and green sea turtles are vulnerable to entrainment in the draghead of the hopper dredge. Given their large size, leatherback sea turtles are not vulnerable to entrainment. As reported by USACE, no leatherback sea turtles have been entrained in hopper dredge operations operating along the U.S. Atlantic coast (USACE Sea Turtle Warehouse, 2017). The areas to be dredged in Reaches D and E are part of the summer developmental habitat of juvenile sea turtles and are used by turtles for foraging. Sea turtles are likely to be feeding on or near the bottom of the water column during the warmer months, with loggerhead and Kemp's ridley sea turtles being the most common species in these waters. Although not expected to be as numerous as loggerheads and Kemp's ridleys, green sea turtles are also likely to occur seasonally in Reach D and E.

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

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

Sea turtles may become entrained in hopper dredges as the draghead moves along the bottom.

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

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

Sea turtles have been killed in hopper dredge operations along the East and Gulf coasts of the US. Documented turtle mortalities during dredging operations in the USACE South Atlantic Division (SAD; i.e., south of the Virginia/North Carolina border) are more common than in the USACE North Atlantic Division (NAD; Virginia-Maine) presumably due to the greater abundance of turtles in these waters and the greater frequency of hopper dredge operations. For example, in the USACE SAD, over 480 sea turtles have been entrained in hopper dredges since 1980 and in the Gulf Region over 200 sea turtles have been killed since 1995. Records of sea turtle entrainment in the USACE NAD began in 1994. Through October 2015, 85 sea turtles deaths (see Table 12) related to hopper dredge activities have been recorded in waters north of the North Carolina/Virginia border (USACE Sea Turtle Database[14]); the majority of these turtles have been entrained in dredges operating in Chesapeake Bay.

Interactions are likely to be most numerous in areas where sea turtles are resting or foraging on the bottom. When sea turtles are at the surface, or within the water column, they are not likely to interact with the dredge because there is little, if any, suction force in the water column. Sea turtles have been found resting on the ocean bottom in deeper waters, which could increase the likelihood of interactions from dredging activities. In 1981, observers documented the take of 71

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

loggerheads by a hopper dredge at the Port Canaveral Ship Channel, Florida (Slay and Richardson 1988). This channel is a deep, low productivity environment in the Southeast Atlantic where sea turtles are known to rest on the bottom, making them extremely vulnerable to entrainment. The large number of turtle mortalities at the Port Canaveral Ship Channel in the early 1980s resulted in part from turtles being buried in the soft bottom mud, a behavior known as brumation. Since 1981, 77 loggerhead sea turtles have been taken by hopper dredge operations in the Port Canaveral Ship Channel, Florida. Chelonid turtles have been found to make use of deeper, less productive channels as resting areas that afford protection from predators because of the low energy, deep water conditions. Habitat in the action area is not consistent with areas where sea turtle brumation has been documented; therefore, we do not anticipate any sea turtle brumation in the action area. Very few interactions with sea turtles have been recorded in Delaware Bay. This may be because the area where the dredge is operating is more wide-open providing more opportunities for escape from the dredge as compared to a narrow river or harbor entrance.

On a hopper dredge without UXO screens, it is possible to monitor entrainment because the dredged material is retained on the vessels as opposed to the direct placement of dredged material both overboard or in confined disposal facilities by a hydraulic pipeline dredge. A hopper dredge contains screened inflow cages from which an observer can inspect recently dredged contents. Typically, the observer inspection is performed at the completion of each load while the vessel is transiting to the authorized placement area and does not impact production of the dredging operations.

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

Of the 10 sea turtle mortalities attributed to hopper dredge operations outside of the Norfolk District since 1992, 6 have occurred in the Philadelphia District, 3 in the Baltimore District and 1 in the New York District. The USACE Philadelphia District started an Endangered Species Monitoring Program in 1992 (USACE 2009a). For four hopper dredging projects conducted in 1992 – 1994, observers were present to provide approximately 25 percent 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 percent. On November 3, 1995, one loggerhead was taken by a hopper dredge operating in the entrance channel. In 1999, dredging occurred in July at the entrance channel. Three decomposed loggerheads were observed at Brandywine Shoal and Reedy Island by the dredge observer while the dredge was transiting to the disposal site. There is no evidence to suggest that these turtles were killed during dredging operations. On July 27, 2005 fresh loggerhead parts were observed in two different dredge loads while dredging was being conducted in the Miah Maull Range of the channel in Delaware Bay. It is currently unknown whether these were parts of the same turtle or two different turtles.

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

Table 12: Sea Turtle Takes in USACE NAD Dredging Operations without UXO screens*

Project Location	**Year of Operation**	**Cubic Yardage Removed**	**Observed Takes**
York Spit Channel	2015	1,747,000	6 loggerheads
Cape Henry Channel	2014	1,640,000	3 Loggerheads 1 Kemp's ridley
Sandbridge Shoal	2013	2,200,000	1 loggerhead[15]
Cape Henry Channel	2012	1,190,004	1 loggerhead
York Spit	2012	145,332	1 Loggerhead
Thimble Shoal Channel	2009	473,900	3 Loggerheads
York Spit	2007	608,000	1 Kemp's Ridley

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[15] Sea turtle observed in cage on beach (material pumped directly to beach from dredge)

Project Location	**Year of Operation**	**Cubic Yardage Removed**	**Observed Takes**
Cape Henry	2006	447,238	3 Loggerheads
Thimble Shoal Channel	2006	300,000	1 loggerhead
Delaware Bay	2005	50,000	2 Loggerheads
Thimble Shoal Channel	2003	1,828,312	7 Loggerheads 1 Kemp's ridley 1 unknown
Cape Henry	2002	1,407,814	7 Loggerheads 1 Kemp's ridley 1 green
York Spit Channel	2002	911,406	8 Loggerheads 1 Kemp's ridley
Cape Henry	2001	1,641,140	2 loggerheads 1 Kemp's ridley
VA Beach Hurricane Protection Project (Thimble Shoals)	2001	4,000,000	5 loggerheads 1 unknown
Thimble Shoal Channel	2000	831,761	2 loggerheads 1 unknown
York River Entrance Channel	1998	672,536	6 loggerheads
Atlantic Coast of NJ	1997	1,000,000	1 Loggerhead
Thimble Shoal Channel	1996	529,301	1 loggerhead
Delaware Bay	1995	218,151	1 Loggerhead
Cape Henry	1994	552,671	4 loggerheads 1 unknown
York Spit Channel	1994	61,299	4 loggerheads
Delaware Bay	1994	2,830,000	1 Loggerhead
Delaware Bay	1993	415,000	2 Loggerheads
Off Ocean City MD	1992	1,592,262	3 Loggerheads
			TOTAL **= 86 Turtles**

*adapted from table provided by USACE on July 18, 2017 and updated October 16, 2017

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 percent of the dredge activity (i.e., 8 hours on watch, 8 hours off watch). As such, if the observer was off watch or the cage was emptied and not inspected or the dredge company either did not report or was unable to identify the turtle incident, there is the possibility that a turtle could be taken by the dredge and go unnoticed. Additionally, in older Opinions (i.e., prior to 1995), we frequently only required 25 percent observer coverage and monitoring of the overflows which has since been determined to not be as effective as monitoring of the intakes. These conditions may have led to sea turtle takes going undetected.

We raised this issue to the USACE Norfolk District during the 2002 season, after several turtles were taken in the Cape Henry and York Spit Channels, and expressed the need for 100 percent observer coverage. On September 30, 2002, the USACE informed the dredge contractor that when the observer was not present, the cage should not be opened unless it is clogged. This modification was to ensure that any sea turtles that were taken on the intake screen (or in the cage area) would remain there until the observer evaluated the load. USACE's letter further stated "Crew members will only go into the cage and remove wood, rocks, and man-made debris; any aquatic biological material is left in the cage for the observer to document and clear out when they return on duty. In addition, the observer is the only one allowed to clean off the overflow screen. This practice provides us with 100 percent 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 percent observer coverage is attained is to have a NMFS-approved endangered species observer monitoring all loads at all times. This level of observer coverage would document all turtle interactions and better quantify the impact of dredging on turtle populations.

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

Due to the nature of interactions between listed species and dredge operations, it is difficult to predict the number of interactions that are likely to occur from a particular dredging operation. Projects that occur in an identical location with the same equipment year after year may result in interactions in some years and none in other years as noted above in the examples of sea turtle takes. Dredging operations may go on for months, with sea turtle takes occurring intermittently throughout the duration of the action. For example, dredging occurred at Cape Henry over 160 days in 2002 with 8 sea turtle takes occurring over three separate weeks while dredging at York Spit in 1994 resulted in 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 (e.g., 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 time of year when the dredging occurs influence the number of interactions (with more interactions correlated to times of year when more sea turtles are present in the action area). The type of dredge plant used also determine the chance of a turtle being taken (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). Uneven terrain or spot dredging (e.g., when the dredge is moved around to target smaller areas that needs dredging) may also influence the number of interactions as interactions are 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 percent observer coverage. Since 1995, observers have provided continuous 8-hour on 8-hour off coverage. Cages are generally not cleaned without the observer being present, so it is likely that greater than 50 percent of material has been observed and that the number of entrainments that go undetected is low. Therefore, while observers are only on watch for 50 percent of dredge operations, the requirement that cages not be cleaned by anyone other than the observer and that the observer be brought on deck if a turtle is observed while the observer is off-watch, results in a much higher percentage of coverage. Six sea turtles have been entrained in hopper dredges operating in Delaware Bay since 1993. As sea turtles have been documented in the action area and suitable habitat and forage items are present, it is likely that sea turtles will be present in the action area when dredging takes place.

We have compiled a dataset representing all of the hopper dredge projects in the Philadelphia District that have reported the cubic yardage removed as well as the number of takes observed. Records for 12 projects occurring during “sea turtle season” (i.e., May – November 15) in the Philadelphia District are available that report the cubic yardage removed during a project. Of these, seven projects involved dredging in the Philadelphia to the Sea navigation channel and five involved dredging off the Atlantic coast of Delaware. The distribution of sea turtles in offshore locations such as offshore borrow areas used for beach nourishment is not expected to be comparable to the distribution of sea turtles in estuarine foraging areas such as Delaware Bay. Additionally, as evidenced in the sea turtle database, very few sea turtles have been entrained in hopper dredges operating at any offshore borrow area. This is true even in the southeast, where large numbers of sea turtles are present year round. This is likely due to the transitory nature of most sea turtles occurring in offshore borrow areas as well as the widely distributed nature of sea turtles in offshore waters. It should also be noted that UXO screens are used when dredging borrow areas to obtain sand for beach nourishment. The UXO screens effectively hinder turtles from entering the dredge and only smaller turtle parts may be transported through the dredge. Thus, observers are unlikely to be able to record any turtle mortalities. As such, we have excluded the five projects involving dredging off the Atlantic coast of Delaware from the dataset used to estimate an entrainment rate for sea turtles in hopper dredges operating in Delaware Bay (see Table 13 below).

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

Table 13: Sea turtle entrainment from Philadelphia District dredging operations in DE Bay*

Project	**Dates**	**CY Removed**	**Observed Entrainment**	**Adjusted Entrainment Number**
Philadelphia to the Sea – Contract 7 Deepening of Lower Reach E	April 2015 to March 2016	1,800,000	0	0
Philadelphia to the Sea – Contract 4 Deepening of Reach D	February 2013 - November 2013	1,134,630	0	0
Philadelphia to the Sea – Contract 4 Deepening of Reach D	February – June 2013	1,149,946	0	0
Philadelphia to the Sea – Miah Maull, Brandywine, Deepwater and Liston ranges	08/08/06 - 08/23/06; 09/07/06 - 11/16/06	390,000	0	0
Philadelphia to the Sea – Brandywine and Deepwater Ranges	11/01/2005 - 11/18/2005	167,982	0	0
Philadelphia to the Sea – Miah Maull and Brandwine	10/04/05 - 10/22/2005	162,682	0	0
Philadelphia to the Sea 40’ Maintenance	2004	50,000	0	0
Philadelphia to the Sea 40’ Maintenance	2002	50,000	0	0
Philadelphia to the Sea 40’ Maintenance	2001	50,000	0	0
Philadelphia to the Sea – Miah Maull	7/24/05 - 7/27/05	50,000	2	2
Philadelphia to the Sea – Miah Maull and Brandywine	10/07/95 -11/16/95	218,151	1	1
Philadelphia to the Sea – Miah Maul	McFarland 6/15/94-8/10/94	2,830,000	1	2

Project	Dates	CY Removed	Observed Entrainment	Adjusted Entrainment Number
Cape May Inlet Beachfill – Brandywine Range	07/24/93 - 08/19/93	415,000	2	4
TOTAL		8,468,391	6	9

*adapted from table provided by USACE on July 18, 2017 and updated October 16, 2017

7.1.1.2 Predicted Entrainment in Proposed Hopper Dredging

Based on the data in Table 13, we have made calculations which indicate that an average of one sea turtle is killed for approximately every 941,000 cy removed[16]. 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 941,000 cubic yards of material removed by a hopper dredge. While this estimate is based on several assumptions, it is reasonable because it uses the best available information on entrainment of sea turtles from past dredging operations in the action area, including channel reaches that are contained within Reaches D and E, and includes multiple projects over several years, all of which have had observer coverage.

With the exception of one green turtle entrained in a hopper dredge operating in Chesapeake Bay, all other sea turtles entrained in dredges operating in the USACE NAD have been loggerheads and Kemp's ridley. Of these 86 sea turtles, 75 have been loggerheads (87%), 6 have been Kemp's ridleys (7%), 1 green (1%) and 4 unknown (5%). No Kemp's ridleys or greens have been entrained in dredge operations outside of the Chesapeake Bay. 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.

Maintenance dredging of 400,000 cy from Reach E will occur on an annual basis, and maintenance dredging of 1,000,000 cy from Reach D will occur on a 3-year cycle. These volumes include the dredging of material for beneficial uses (Oakwood beach nourishment and the DMU study). Assuming a worst case scenario that all dredging occurs when sea turtles are present in the action area (between May and November), and based on the information outlined

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[16] This is calculated by dividing the total number of cy of material removed (8,468,391) by the adjusted number of sea turtle entrainments (9). This results in 1 sea turtle per 940,932 cy removed in Delaware Bay.

above and the volume of material estimated to be removed, we anticipate the following entrainment:

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

Reach	**Scheduled Dates**	**Dredge Frequency**	**Number of Events from 2017-2068**	**Volume (cy) per Dredge Event**	**Volume (cy) from 2019-2068**
E (Maintenance of 45’)	Year-round	Annual	50	400,000	20,000,000
D (Maintenance of 45’)	Year-round	3-year cycle	17	1,000,000	17,000,000
				Total Volume (cy):	**37,000,000**
				Anticipated Sea Turtle Takes:	39.3

As such, we anticipate that no more than 40 (rounded up as a fraction of turtle cannot be captured and to be conservative) sea turtles are likely to be entrained during the deepening and maintenance dredging of the 45-foot channel in Reaches E and D from 2019-2068. 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 87 percent of the sea turtles taken in dredges operating in the USACE North Atlantic Division have been loggerheads. Therefore, we also assume that the four unknown (5%) were loggerheads (i.e., 92 percent of the sea turtles were loggerheads). Based on the ratio of sea turtle entrainment in the USACE NAD, no more than three (3) of the sea turtles likely to be entrained in a hopper dredge will be a Kemp’s ridley, with the remainder (37) being loggerheads. As noted above, interactions with green sea turtles are extremely rare and have never been reported in the Delaware Bay, thus, we do not expect any to occur.

7.1.2 Entrainment in Hopper Dredges – Sturgeon

Sturgeon are vulnerable to entrainment in hopper dredges. Entrainment is believed to occur primarily when the draghead is not in firm contact with the channel bottom, so the potential exists that sturgeon feeding or resting on or near the bottom may be vulnerable to entrainment. Additionally, the size and flow rates produced by the suction power of the dredge, the condition of the channel being dredged, and the method of operation of the dredge and draghead all relate to the potential of the dredge to entrain sturgeon (Reine *et al.* 2014). These parameters also govern the ability of the dredge to entrain other species of fish, sea turtles, and shellfish.

The risk of interactions is related to both the amount of time sturgeon spend on the bottom and the behavior the fish are engaged in (i.e., whether the fish are overwintering, foraging, resting or migrating) as well as the intake velocity and swimming abilities of sturgeon in the area (Clarke

2011). Intake velocities at a typical large self-propelled hopper dredge are 11 feet per second. As noted above, exposure to the suction of the draghead intake is minimized by not turning on the suction until the draghead is properly seated on the bottom sediments and by maintaining contact between the draghead and the bottom.

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

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

Entrainment of sturgeon during hopper dredging operations in Federal navigation channels appears to be relatively rare. From 1990-2012, USACE documented 28 incidents of sturgeon entrainment on monitored hopper dredges (see Appendix A). Of these, 20 were Atlantic sturgeon, five were shortnose and two were Gulf sturgeon (one unknown). Since that report was generated, one Atlantic sturgeon was entrained in the Ambrose Channel, New York (October 2012; alive); one Atlantic sturgeon was entrained in the Delaware River in May 2013 (released alive); five sturgeon were entrained in the Delaware River by hopper dredges in 2014.; two sturgeon were entrained in 2017; and two Atlantic sturgeon and one shortnose sturgeon were entrained in 2018. In 2014, four of the entrainments occurred during maintenance of the 40’ Philadelphia to the Sea channel in areas that had not been deepened (May – dead juvenile Atlantic; August – dead adult Atlantic; September – dead juvenile Atlantic; October – dead juvenile Atlantic) and one of the five (November – live juvenile Atlantic) occurred during maintenance of the 45’ channel. In 2017, one entrainment occurred during maintenance of the Philadelphia to Trenton 40’ channel (July – dead adult shortnose) and the other during maintenance of the Philadelphia to the Sea 45’ channel (October – dead juvenile Atlantic). Additional details on these interactions are presented in the table below. In 2018, one of three entrainments occurred during maintenance of the Philadelphia to Trenton 40’ channel (October –

dead juvenile Atlantic) and the two other were entrained during maintenance of Philadelphia to Sea 45’ channel (November – dead juvenile Atlantic and dead adult shortnose). However, we do not have information on the volume dredged during 2018 and these takes are not included in Table 15. Additionally, part of a decomposed sturgeon was entrained in a hopper dredge in Delaware River in September 2013. With the exception of the adult Atlantic sturgeon entrained in August 2014[17], all recorded interactions with Atlantic sturgeon have been with juveniles or subadults (length <150 cm). Given the large size of Atlantic sturgeon adults (greater than 150cm) and the size of the openings on the dragheads used for this action (openings no greater than 4” x 4”), adult Atlantic sturgeon are unlikely to be vulnerable to entrainment.

As explained above, since 1992, endangered species observers have been present for at least a portion of all hopper dredging done during the June – November time frame below the Delaware Memorial Bridge (i.e., Reaches D and E); no sturgeon have been observed during dredging activities in Reaches D or E, including deepening that occurred in Reach E from April to August 2015. Observers have been placed on hopper dredges operating in Reaches AA and A since 2012. To date, nine sturgeon interactions have been recorded including the entrainment of a decomposed sturgeon (not a take) in 2013.

Table 15: Sturgeon takes from hopper dredging with observer coverage in Delaware River since 1992*

Dredging Activity	**Dredging Dates**	**CY Removed**	**Date of Take**	**Species**
Cape May Inlet Beachfill – Brandywine Range	07/24/93 - 08/19/93	415,000	N/A	N/A
Philadelphia to the Sea – Miah Maull	6/15/94-8/10/94	2,830,000	N/A	N/A
Philadelphia to the Sea – Miah Maull and Brandywine	10/07/95 - 11/16/95	218,151	N/A	N/A
Philadelphia to the Sea 40’ Maintenance	2001	50,000	N/A	N/A
Philadelphia to the Sea 40’ Maintenance	2002	50,000	N/A	N/A
Philadelphia to the Sea 40’ Maintenance	2004	50,000	N/A	
Philadelphia to the Sea – Miah Maull	7/24/05 - 7/27/05	50,000	N/A	N/A
Philadelphia to the Sea – Miah Maull and Brandwine	10/04/05 - 10/22/2005	162,682	N/A	N/A

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[17] The draghead operating on August 31, 2014 in the Philadelphia to Trenton reach had 10” x 10” openings.

Dredging Activity	Dredging Dates	CY Removed	Date of Take	Species
Philadelphia to the Sea – Brandywine and Deepwater Ranges	11/01/2005 - 11/18/2005	167,982	N/A	N/A
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	N/A	N/A
Philadelphia to Sea Maintenance Dredging Marcus Hook and New Castle Ranges	November - December 2011	1,216,106	N/A	N/A
Philadelphia to Sea Maintenance Dredging Marcus Hook and New Castle Ranges	September - December 2012	2,011,018	N/A	N/A
Philadelphia to the Sea – Contract 3 Deepening of Upper Reach A Cutter and Hopper Dredge	September 2012 to February 2013	1,259,165	N/A	N/A
Philadelphia to the Sea – Contract 4 Deepening of Reach D	February – June 2013	1,149,946	N/A	N/A
Maintenance of 40’ Philadelphia to Sea channel (Reach AA)	May - July 2013	137,799	5/11/2013	1 Atlantic (live)
Philadelphia to the Sea – Contract 4 Deepening of Reach D Hopper and Bucket Dredge	February - November 2013	1,134,630	N/A	N/A
Maintenance of 40’ Philadelphia to Sea channel (Reach B - Tinicum Range)	April - May 2014	98,175	5/16/2014	1 Atlantic (dead)
Philadelphia to Sea Maintenance Dredging Marcus Hook, Deepwater and New Castle Ranges	September 2013 - May 2014	2,852,045	N/A	N/A
Maintenance of 40' Philadelphia to Sea - Philadelphia Harbor	June - July 2014	55,379	N/A	N/A

Dredging Activity	**Dredging Dates**	**CY Removed**	**Date of Take**	**Species**
Philadelphia to the Sea – Contract 5 Deepening of Lower Reach A Hopper Dredge	July - October 2014	381,188	N/A	N/A
Maintenance of 40’ Philadelphia to Trenton channel	August - October 2014	100,000	8/31/2014	1 Atlantic (dead)
Maintenance of 40’ Philadelphia to Trenton channel	August - October 2014	100,000	9/1/2014	1 Atlantic (dead)
Maintenance of 40’ Philadelphia to Sea channel (Reach A - Mifflin Range)*	October - November 2014	62,472	10/24/2014	1 Atlantic (dead)
			11/26/2014	1 Atlantic (live)
Maintenance of 40’ Philadelphia to Sea channel (Reach A - Mifflin Range)*	December 2014	71,716	N/A	N/A
Philadelphia to Sea Maintenance Dredging Marcus Hook and New Castle Ranges	November 2014 - February 2015	2,242,636	N/A	N/A
Philadelphia to Trenton Lower Reach	July - September 2015	125,000	N/A	N/A
Maintenance of 40' Philadelphia to Sea Philadelphia Harbor	October - November 2015	57,590	N/A	N/A
Philadelphia to the Sea – Contract 7 Deepening of Lower Reach E Hopper Dredge	April 2015 to March 2016	1,800,000	N/A	N/A
Philadelphia to Sea Maintenance Dredging Marcus Hook and New Castle Ranges	September 2015 - March 2016	1,964,149	N/A	N/A
Maintenance of 40' Philadelphia to Sea Marcus Hook Anchorage	April - May 2016	118,287	N/A	N/A
Maintenance of 40' Philadelphia to Sea	March - May 2017	209,136	N/A	N/A

Dredging Activity	**Dredging Dates**	**CY Removed**	**Date of Take**	**Species**
Marcus Hook Anchorage				
Philadelphia to Sea Maintenance Dredging Marcus Hook Range	July 2017	1,161,695	N/A	N/A
Philadelphia to Sea Maintenance Dredging Deepwater Point Range	September 2017	2,047,501	N/A	N/A
Philadelphia to Sea Maintenance Dredging New Castle Range	September 2017	729,029	N/A	N/A
Philadelphia to the Sea - 45' Maintenance (Tinicum Range, Reach A)	October – December 2017 (ongoing)	1,300,000	10/2/2017	1 Atlantic (dead)
Maintenance of 40' Philadelphia to Trenton	July 1, 2017 – December 31, 2017	143,684	7/8/2017	1 Shortnose (dead)
Total:		**26,849,689**		**8**

*adapted from table provided by USACE on July 18, 2017 and updated October 16, 2017

As described in the discussion of sea turtles above, many other hopper dredge projects have occurred in NMFS Greater Atlantic Region; nearly all of which overlap with times and areas where Atlantic or shortnose sturgeon are known to be present. Because observers have been present on these dredges and interactions with sturgeon are required to be reported to us, any interactions with sturgeon would have been reported to us. A total of 17 sturgeon (6 shortnose; and 11 Atlantics: 2 in York Spit, VA, 1 in Sandy Hook, NJ, 1 in Ambrose Channel, NY and 7 in Delaware River), have been observed as entrained in hopper dredges in the GAR, with eight occurring in the Delaware River/action area (see Table 15).

7.1.2.1 Anticipated Entrainment of Shortnose and Atlantic sturgeon in Hopper Dredges During Deepening and Maintenance Dredging

As explained above, since 1992, endangered species observers have been present for at least a portion of all hopper dredging done during the June – November time frame below the Delaware Memorial Bridge (i.e., Reaches D and E). No shortnose or Atlantic sturgeon have been documented during hopper dredge activities in Reaches D and E in the Philadelphia to the Sea channel maintenance. Deepening of Reach D was completed in 2013; over 2 million cy of material was removed and no sturgeon were observed. Deepening of lower Reach E began in April 2015 and was completed in March 2016. 1,800,000 cy were dredged and no sturgeon were observed. 1,300,000 cy (~750 acres) was dredged for the deepening of upper Reach E and no take was reported. Future maintenance dredging of Reaches D and E will occur year-round.

Atlantic and shortnose sturgeon are known to occur in Reach D and E, and while no entrainment of sturgeon has been observed, it is still possible. The reduced risk of entrainment in these reaches is likely due to the life stages of sturgeon using these reaches (mainly larger salinity tolerant juveniles and adults), the known use of areas outside the channel rather than in the channel (O'Herron and Hastings 1985), and the availability of habitat outside of the area where dredging is occurring (the river and bay are wider in these reaches compared to reaches upstream where the river is more narrow outside of the channel), which may increase the potential for sturgeon to escape from the dredge.

Hopper dredging (deepening and maintenance) will also occur in the upper reaches of the Philadelphia to the Sea navigation channel river (i.e., Reaches AA, A, B and C), as well as in the Philadelphia to Trenton navigation channel (Reach A-B). In Reach C, hopper dredging may occur year-round, and in Reach A-B, hopper dredging may occur from June 1 – March 15. In the remaining Reaches, hopper dredging may occur from July 1 – March 15.

You have indicated that the vast majority of deepening (aside from rock blasting and clean-up in Reach B) and maintenance dredging of shoals will remove soft substrates (see Table 2). Occasionally, you encounter gravel and small cobbles in small edge shoaling areas (e.g., near Eddystone and Philadelphia Harbor) that require dredging on a less frequent basis (i.e., once every few years). As discussed in the Environmental Baseline, while the edges of these shoals may have some hard substrate and, if in freshwater, could theoretically be used for spawning, settlement of eggs or refuge or development of larvae, we do not expect Atlantic sturgeon adults to select these areas for spawning and therefore, do not expect eggs or yolk-sac larvae to be present in these shoals. Post yolk-sac larvae occur over a variety of substrate types and may be present near these shoals. If there are interstitial spaces between gravel and cobble, this life stage may use the portions of these shoals with hard substrates for refuge. However, the dynamic nature of these shoals reduces the likelihood that these habitats would be selected by post yolk-sac larvae.

Adult and subadult Atlantic sturgeon are most likely to be present in Reaches C and above from April to November, as they spend winter months in the lower estuary/bay, or other ocean aggregation areas. Juveniles and young-of-year could be present year-round (young-of-year would stay about the salt front). Based on telemetered movements of spawning Atlantic sturgeon adults, spawning occurs from April through July, from RKM 125-212 (Reaches A-B, AA, A, and B). Therefore, Atlantic sturgeon eggs and yolk-sac larvae could be present in spawning habitat from April through August. Post-yolk sac larvae could be present throughout from May through September.

Adult, juvenile, and young-of-year shortnose sturgeon may be present in Reaches C and above year-round (young-of-year would stay about the salt front). Shortnose sturgeon do not spawn in reaches impacted by proposed hopper dredging, so eggs and yolk-sac larvae will not be affected. Post yolk-sac larvae, while more likely to occur upstream, could be in Reach A-B from mid-

April through July.

7.1.2.1 Deepening and Maintenance Dredging Effects to Post Yolk-Sac Larvae (PYSL)

Post yolk-sac larvae (PYSL) are free swimming, prefer the deepest parts of the river, may seek refuge in hard bottom substrate, and begin to forage in soft substrates. This habitat is similar to that found in the navigation channels. Given the limited mobility of PYSL, we expect the risk of entrainment and/or capture of PYSL to be the same regardless of dredge type. Therefore, rather than consider interactions between PYSL and the various dredge types used for deepening and maintenance dredging separately, we address all dredge types here. Effects to PYSL from clean-up dredging are addressed in section 7.3.

Routine maintenance dredging in freshwater reaches of the river is expected to occur during the time of year when PYSL will be present in those reaches. Additionally, the remaining deepening in Reach B is scheduled to occur during the time of year when PYSL would be present in that area. As explained above, PYSL are only present in the river between April and September, with the exact dates depending on when spawning begins and ends in a particular year. No dredging or deepening in freshwater reaches is anticipated to occur between April 1 and May 31 of any year; therefore, PYSL would only be exposed to dredging operations if they occur from June through September.

Therefore, entrainment/entrapment in a dredge is a risk for shortnose sturgeon PYSL in Reach A-B (Alleghany Ave. to Burlington Island) from June 1 to July 31 and in Reaches A-B (Burlington Island to Newbold Island) and B-C from July 1-July 31. Atlantic sturgeon PYSL is at risk of entrainment/entrapment in a dredge in Reaches B, A, AA, A-B (Burlington Island to Newbold Island), and B-C from July 1 – September 30, and Reach A-B (Alleghany Ave. to Burlington Island) from June 1 – September 30.

PYSL are expected to be near the bottom of the river, either foraging over soft substrates or resting/seeking refuge within hard substrates with big enough interstitial spaces to provide cover. Given the small size of PYSL (15-57mm for shortnose; 14-37mm for Atlantics), and the intake velocity of cutterhead and hopper dredges (~11 ft/sec for a hopper; ~4.6m/second for a cutterhead), it is unlikely that a PYSL that is over or within substrates being removed by the dredge could avoid entrainment. Additionally, the possible size of openings in the hopper draghead (no greater than 101.6mm x 101.6mm or 4” x 4”) and the cutterhead suction pipe (~30”) would not provide any screening or protection from entrainment. PYSL may have a higher likelihood of escaping a mechanical dredge bucket than a cutterhead or hopper dredge as they may be able to react to the dredge bucket as it moves through the water column towards the bottom, however, given their limited mobility and small size, it is likely that PYSL present in the area being dredged would be captured by the dredge bucket. Cutterhead and hopper dredge operators will minimize exposure to the suction of the draghead/cutterhead intake by not turning on the suction until the draghead/cutterhead is properly seated on the bottom sediments and by doing their best to maintain contact between the draghead and the bottom; however, if PYSL are right at the bottom or are settled into areas of cobble or gravel, this may offer little protection.

To date, monitoring of entrainment of sturgeon larvae has not occurred. There is very limited information on the risk of fish larvae to dredge entrainment generally and we are not aware of any studies on the entrainment of sturgeon larvae during dredging with the exception of one study in Russia which does not provide enough information to provide any insights on risk (Veshchev 1981, as cited in USACE DOER 1998). We also do not have any estimates for the numbers of post yolk-sac larvae (for either species) that may occur in the navigation channel from June-September. Therefore, in order to assess the impacts of dredge entrainment on PYSL we need to make a number of assumptions. First, we assume that any PYSL that are present in the areas being dredged will be entrained and that the mortality rate will be high. These are reasonable assumptions give the limited ability of PYSL to avoid the dredge intake, as well as the almost certain mortality due to suffocation or burial within the sediments either in the dredge hopper or at the disposal site. Because we do not know how many PYSL will be present in the areas to be dredged we cannot determine the number that will be entrained. However, we can make a reasonable prediction of the proportion of the total PYSL in a particular year class that are likely to be entrained in a dredge. To make this prediction, and because we do not have the information to determine exactly when and where PYSL will be present at any given time, we must make assumptions about the spatial and temporal distribution of PYSL in the river. These assumptions are informed by what we know about the seasonal presence of this life stage (i.e., based on when we expect spawning to occur we can calculate the time of year when PYSL would be present in the river) and by what we know about where PYSL would occur in the river (i.e., only within freshwater, but not limited to the hard substrates where eggs and yolk-sac larvae are present).

Given this information, we assume that Atlantic sturgeon post yolk-sac larvae are evenly distributed temporally (i.e., across the months of May-September) and spatially (within the mainstem Delaware River between the upstream limit of potential spawning grounds (RKM 212) and the salt front (RKM 107.8)) throughout the space and time when and where this lifestage can occur in the river. These are reasonable assumptions because we know that spawning is spread out over time (e.g., see tracking of spawning condition Atlantic sturgeon adults in Breece *et al.* 2013) and therefore, an entire year class will not transition from one life stage to another all at the same time, but rather over a range of time. In addition, we also know that not all spawning happens in one place, which provides some distribution of early life stages; because PYSL move away from the spawning sites, but are still restricted to freshwater (ASSRT 2007), they could occur throughout the freshwater reach.

We conducted an ArcGIS analysis to approximate the bank-to-bank area of the Delaware River from RKM 212 to RKM 107.8, and arrived at an estimated area of 28,436 acres where Atlantic sturgeon post yolk-sac larvae may be present during the May – September period. No dredging in areas with PYSL is proposed in May, so assuming that an equal amount of PYSL are present in each of the five months when this life stage could be present in the river, 20 percent of each year class will not be exposed to dredging effects.

Annual maintenance dredging in Reach A-B (Alleghany Ave. to Burlington Island) may overlap with Atlantic sturgeon PYSL from June – September (80% of the time the year class may be present), and will target shoals that are approximately 63.4 acres in size (0.2% of the total area where PYSL may be distributed). Therefore, we estimate that 0.2 percent (i.e., 0.8 x 0.02 = 0.016, rounded to the nearest tenth of a percent) of the Atlantic sturgeon PYSL year class will be killed due to maintenance dredging in Reach A-B (Alleghany Ave. to Burlington Island) each year (for the proposed project duration of 50 years).

Annual maintenance dredging in the remaining reaches where Atlantic sturgeon PYSL may be present may occur between July and September (60% of the time the year class may be present), and will target shoals that are approximately 524.3 acres in size (1.8% of the total area where PYSL may be distributed). Therefore, we estimate that 1.1 percent (i.e., 0.6 x 0.018 = 0.0108, rounded to the nearest tenth of a percent) of the PYSL year class will be killed due to maintenance dredging in Reaches B, A, AA, A-B (Burlington Island to Newbold Island), and B-C each year (for the proposed project duration of 50 years).

The remaining deepening in Reach B between RKM 125.5 and 135.2 will take place between July 1, 2019 and March 15, 2020, and may co-occur with Atlantic sturgeon PYSL between July and September (60% of the time the year class may be present). The dredging will remove approximately 100 acres (0.35% of the total area where PYSL may be distributed). Therefore, we estimate that 0.21 percent (i.e., 0.6 x 0.0035 = 0.0021) of the 2018 PYSL year class will be killed due to remaining deepening activities in Reach B.

In total, the deepening and annual maintenance dredging will result in the mortality of 1.51 percent of the Atlantic sturgeon PYSL 2019 year class and 1.3 percent of each PYSL year class from 2020 through 2068.

Similarly, for shortnose sturgeon, we assume that PYSL are evenly distributed temporally (i.e., across the months of mid-April through July) and spatially (within the mainstem Delaware River between the upstream limit of the action area (RKM 214.5) and the lower part of Reach A-B (RKM 177)) throughout the space and time when and where this lifestage can occur in the river. These are reasonable assumptions because we know that spawning is spread out over time (e.g., see tracking of spawning condition shortnose sturgeon adults in ERC 2008) and therefore, an entire year class will not transition from one life stage to another all at the same time, but rather over a range of time. We also know that not all spawning happens in one place, which provides some distribution of early life stages; because PYSL move away from the spawning sites, but are still restricted to freshwater (SSSRT 2010), they could occur throughout the freshwater reach.

We conducted an ArcGIS analysis to approximate the bank-to-bank area of the Delaware River from RKM 214.5 to RKM 177, and arrived at an estimated area of 3,879 acres where shortnose sturgeon PYSL may be present in the action area during the mid-April through July period. Shortnose sturgeon may spawn as far upstream as Lambertville, New Jersey (RKM 238), meaning that there is significantly more area where PYSL could be present and unaffected by the action; however, we only focus on effects within the action area.

No dredging in areas with PYSL is proposed in April or May, so approximately 40 percent (i.e., 6 out of 14 weeks) of each year class will not be exposed to dredging. Annual maintenance dredging in Reach A-B may overlap with shortnose sturgeon PYSL from June – July (60% of the time the year class may be present), and will target shoals that are approximately 63.4 acres in size (1.6% of the total area where PYSL may be distributed). Therefore, we estimate that 1 percent (i.e., 0.6 x 0.016 = 0.0096, rounded to the nearest tenth of a percent) of the PYSL in any given year class will be killed during maintenance dredging in Reach A-B each year (for the proposed project duration of 50 years).

Annual maintenance dredging in the remaining reaches may co-occur with PYSL in July (30% (4 out of 14 weeks) of the time the year class may be present), and will target shoals that are approximately 101.3 acres in size (2.6% of the total area where PYSL may be distributed). Therefore, we estimate that 0.8 percent (i.e., 0.3 x 0.026 = 0.0078, rounded to the nearest tenth of a percent) of the PYSL in any year class will be killed during maintenance dredging in Reach A-B each year (for the proposed project duration of 50 years).

In sum, annual maintenance dredging will result in the mortality of approximately 1.8 percent of the PYSL from each shortnose sturgeon year class from 2018 through 2068.

7.1.2.2 Entrainment of Non-Larval Sturgeon in Hopper Dredges

Based on the non-larval sturgeon entrained during the Philadelphia to the Sea and Philadelphia to Trenton maintenance dredging project (see Table 15), we have calculated an entrainment/capture rate of one (1) sturgeon for every 3,356,211 cy of sediment removed via hopper dredge in Reaches E, D, C, B, A, AA, and A-B.[18] As we do not know the relative proportion of Atlantic and shortnose sturgeon in these reaches of the Delaware River, we cannot reliably predict the ratio of shortnose and Atlantics that may be entrained as a result of hopper dredging activities. Therefore, between now and 2068, we anticipate the entrainment of 86 sturgeon at an average rate of 1.7 per year (i.e., a maximum combination of the two species totaling 86 sturgeon). Given the size of screening on the dragheads (4” x 4”), we do not expect any entrainment of adult Atlantic sturgeon. We only expect interactions with juvenile or subadult Atlantic sturgeon. Interactions with shortnose sturgeon could include juveniles or adults.

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 percent; Chesapeake Bay 18 percent; South Atlantic 16.5 percent; Gulf of Maine 7 percent; and Carolina 0.5 percent. Any juvenile Atlantic sturgeon entrained during dredging would originate from the Delaware River (New York Bight DPS). We expect that any subadult Atlantic sturgeon entrained during dredging would occur at these frequencies. In the unlikely event that all of the entrained sturgeon were subadult Atlantic sturgeon, we expect that of the 86, 50 will originate from the New York Bight DPS, 16 from the Chesapeake Bay DPS, 14 from the South Atlantic DPS and 6 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

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[18] This is calculated by dividing the total estimated number of cy of material removed (26,806,005) by the number of sturgeon entrainments documented (8). This results in 1 sturgeon per 3,350,751 cy removed from the Delaware River/Bay. See **Table 15** for details.

Carolina DPS Atlantic sturgeon subadults. All other life stages of Atlantic sturgeon that may be taken would be NYB DPS fish.

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

7.2 Risk of Entrainment in Hydraulic Cutterhead Dredges

7.2.1 Available Information on the Risk of Entrainment of Sea Turtles and Sturgeon in Cutterhead Dredges

Some of the remaining deepening work (Reach B), as well as much of the future maintenance of the 45’ channel from Philadelphia to the Sea (Reaches D to A) and all reaches of the navigation channel from Philadelphia to Trenton may be accomplished with a cutterhead dredge. The use of a cutterhead, hopper, or mechanical dredge depends on dredge equipment availability, costs, shoaling volume, etc. As we noted in Table 1, you have said that hopper, cutterhead, or mechanical dredges may be used for work in most of the Reaches.

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 (USACE https://dots.el.erdc.dren.mil/doer/tools.html). 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). 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.

Sea turtles are not known to be vulnerable to entrainment in cutter head dredges, presumably because they are able to avoid the relatively small intake and low intake velocity. Thus, if a sea turtle were to be present at the dredge site, it would be extremely unlikely to be injured or killed as a result of dredging operations carried out by a hydraulic cutter head dredge. Based on this information, effects to sea turtles from the hydraulic cutter head dredge are discountable.

It is generally assumed that non-larval sturgeon (i.e., young of year or older) 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 that dredge cycle. Since that time, dredging occurring in the winter months in the Newbold – Kinkora range require that inspectors conduct daily inspections of the dredge spoil area in an attempt to detect the presence of any sturgeon. In January 1998, three shortnose sturgeon carcasses were discovered in the Money Island Disposal Area. The sturgeon were found on three separate dates: January 6, January 12, and January 13. Dredging was being conducted in the Kinkora and Florence ranges at this time which also overlaps with the shortnose sturgeon overwintering area. A total of 512,923 cy of material was dredged between Florence and upper Newbold Island during that dredge cycle. While it is possible that not all shortnose sturgeon killed during dredging operations were observed at the dredge disposal pool, USACE has indicated that due to flow patterns in the pool, it is expected that all large material (i.e., sturgeon, logs etc.) will move towards the edges of the pool and be readily observable. Deepening has occurred in Reach C, Reach B and Reach A. Dredging in Reach C occurred from March – September 2010 with 3,594,963 cy of material removed with a cutterhead dredge. Dredging in Reach B occurred in November and December 2011, with 1,100,000 cy of material removed with a cutterhead dredge. Dredging in Reach A occurred from September – February 2013 with the removal of approximately 1.2 million cy of material with a cutterhead dredge. In all cases, the dredge disposal area was inspected daily for the presence of sturgeon. No sturgeon were detected.

In an attempt to understand the behavior of sturgeon while dredging is ongoing, you worked with sturgeon researchers to track the movements of tagged Atlantic and shortnose sturgeon while cutterhead dredge operations were ongoing in Reach B (ERC 2012). 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 did not indicate 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.

Similar studies were carried out in the James River (Virginia) (Barber 2017, Reine *et al.* 2014). 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; showed active and free movement past the dredge during full production mode; showed no signs of avoidance response (e.g., due to noise generated by the dredge) as indicated by the amount of time spent in close proximity to the dredge after release (3.5 – 21.5 hours); and, tagged fish showed no evidence of attraction to the dredge.

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

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

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

The risk of an individual 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. 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. Therefore, shortnose sturgeon in the overwintering aggregations near Duck and Newbold Island (ERC 2007, Fisher 2011) may be most vulnerable to entrainment (Reaches A-B and B-C). Sturgeon outside of these known aggregation areas are more likely to avoid the cutterhead (i.e., less likely individuals will be within 1 meter of the draghead). The tracking of sturgeon movements during cutterhead dredging in Reach B in November and December (ERC 2012) supports this conclusion.

7.2.1.1 *Deepening and Maintenance Dredging Effects to Post Yolk-Sac Larvae (PYSL)*

Because you have proposed to dredge most reaches with several different types of dredge (hopper, cutterhead, and mechanical), and we expect take of PYSL to occur with any dredge type during the times of year discussed above, the analysis in Section 7.1.2 (Deepening and Maintenance Effects to Post Yolk-Sac Larvae (PYSL)) applies to all maintenance and deepening dredging activities, and not just those done with a cutterhead dredge.

To summarize the findings in Section 7.1.2.1, we expect annual maintenance and deepening dredging will result in the lethal take of 1.51 percent of the Atlantic sturgeon PYSL year class in 2019, and 1.3 percent of each Atlantic sturgeon PYSL year class 2020 through 2068.

Annual maintenance dredging will result in the take of 1.8 percent of each shortnose sturgeon PYSL year class from 2019 through 2068.

7.2.1.2 *Cutterhead Dredging Effects to Non-Larval Sturgeon*

In total, approximately 293,150,000 cy of material may be removed with a cutterhead dredge for the remaining deepening and future maintenance dredging of the Philadelphia to the Sea (excluding Reach E) and Philadelphia to Trenton navigation channels. Because the only known 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 future dredging activities. Based on the available information presented here, entrainment of non-larval sturgeon (i.e., young of year or older) in a cutterhead dredge is likely to be rare, and would only occur if a sturgeon was within one meter of the dredge head. 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 sturgeon (shortnose sturgeon or Atlantic sturgeon) will be entrained per year for the remaining deepening and 50 years of future maintenance dredging (through 2068). Therefore, we anticipate the entrainment of no more than 50 shortnose sturgeon or 50 Atlantic sturgeon. In most Reaches, you have proposed to dredge with a hopper or cutterhead dredge. Therefore, these 50 shortnose or 50 Atlantic sturgeon would not be in addition to the estimated moralities discussed in section 7.1.2, but would rather be subtracted from the total estimated moralities of non-larval sturgeon from hopper dredge entrainment.

The entrained shortnose sturgeon could be young of year, juveniles, or adults. The entrained Atlantic sturgeon could be young of year, juveniles or subadults. Using mixed stock analysis explained above, we have determined that subadult Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: NYB 58 percent; Chesapeake Bay 18 percent; South Atlantic 17 percent; Gulf of Maine 7 percent; and Carolina 0.5 percent. We expect that any subadult Atlantic sturgeon entrained during dredging would occur at these frequencies. Thus, in the unlikely event that all of the entrained sturgeon were subadult Atlantic sturgeon, we expect that of the 50, 29 will originate from the New York Bight DPS, 9 from the Chesapeake Bay DPS, 9 from the South Atlantic DPS and 3 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 extremely unlikely that there will be any mortality of any Carolina DPS Atlantic sturgeon subadults. Any juvenile Atlantic sturgeon entrained during dredging would originate from the Delaware River (New York Bight DPS).

We expect all entrained shortnose sturgeon and Atlantic sturgeon to be killed due to the suction, travel through up to three miles of pipe, and any residency period in the disposal area.

7.3 Risk of Capture/Entrapment in Mechanical Dredges

Mechanical maintenance dredging may occur from July 1 – March 15 in Reaches B, A, AA, A-B, B-C, and C-D. After blasting is completed, mechanical dredging will also be used to remove displaced rock debris (also July 1 – March 15).

In 2012, the Corps provided NMFS with a list of all documented interactions between dredges and sturgeon reported along the U.S. East Coast; reports dated as far back as 1990. This list included four incidents of sturgeon captured in dredge buckets. These include the capture of a decomposed Atlantic sturgeon in Wilmington Harbor in 2001. The condition of this fish indicated it was not killed during the dredging operation and was likely dead on the bottom or in the water column and merely scooped up by the dredge bucket. Another record was of the capture of an Atlantic sturgeon in Wilmington Harbor in 1998; however, this record is not verified and not considered reliable. The report also listed the live capture of an Atlantic sturgeon at the Bath Iron Works (BIW) facility in the Kennebec River, Maine in 2001 as well as a shortnose sturgeon captured at BIW in 2003 that was observed to have suffered death recently at the time of capture. One report of a live shortnose sturgeon captured in a dredge bucket at BIW in 2009 was not included in the report. Observer coverage at dredging operations at the BIW facility has been 100 percent for approximately 15 years, with dredging occurring every one to two years. In addition, hundreds of mechanical dredging projects occur along the U.S. Atlantic coast each year and we are not aware of any other captures of sturgeon in mechanical dredges anywhere in the U.S prior to or after 2012.

The risk of interactions between sturgeon and mechanical dredges is thought to be highest in areas where large numbers of sturgeon are known to aggregate. The risk of capture may also be related to the behavior of the sturgeon in the area. While foraging, sturgeon are at the bottom of the river interacting with the sediment. This behavior may increase the susceptibility of capture with a dredge bucket. We also expect the risk of capture to be higher in areas where sturgeon are overwintering in dense aggregations as overwintering sturgeon may be less responsive to stimuli which could reduce the potential for a sturgeon to avoid an oncoming dredge bucket.

Most mobile organisms, including adult and juvenile Atlantic and shortnose sturgeon, are able to avoid mechanical dredge buckets. For a sturgeon to be captured in a bucket dredge, the sturgeon has to be immediately below the bucket and remain stationary as the bucket jaw closes. The slow movement of the dredge bucket through the water column and the relatively small area of bottom impacted by each pass of the bucket makes the likelihood of interaction between a dredge bucket and an individual fish relatively low. Based on all available evidence, the risk of sturgeon being captured in a mechanical dredge is low.

Monitoring has been ongoing at dredging projects associated with the Tappan Zee Bridge replacement project on the Hudson River. The first stage of dredging occurred in 2013. Two dredges were used between August 2 and October 30, 2013 and a total of 844,120 cy of material were removed using a bucket dredge. NMFS-approved observers were present to monitor 100 percent of all dredging. All dredge observer forms were submitted to us on December 31, 2013. While fish and other biological materials were observed in 279 loads (out of approximately 1,500), no shortnose or Atlantic sturgeon were observed. Dredging occurred again in 2015 with approximately 150,000 cy of material removed; observer coverage was 100 percent and no shortnose or Atlantic sturgeon were observed. The area where dredging occurred is a high use area for shortnose and Atlantic sturgeon.

Based on the occurrence of shortnose and Atlantic sturgeon in the area where mechanical dredging will take place and the documented possibility that this species can be captured with mechanical dredges, it is likely that a small number of sturgeon, particularly less mobile early life stages, will be captured by mechanical dredging involved in deepening, maintenance, and clean-up dredging activities.

7.3.1 Deepening and Maintenance Dredging Effects to Post Yolk-Sac Larvae (PYSL)

Because you have proposed to dredge most reaches with several different types of dredge (hopper, cutterhead, and mechanical), and we expect take of PYSL to occur with any dredge type during the times of year discussed above, the analysis in Section 7.1.2 (Deepening and

Maintenance Dredging Effects to Post Yolk-Sac Larvae (PYSL)) applies to all maintenance and deepening dredging activities, and not just those done with a mechanical dredge.

To summarize the findings in Section 7.1.2, we expect annual maintenance and deepening dredging will result in the lethal take of 1.51 percent of the Atlantic sturgeon PYSL year class in 2019, and 1.3 percent of each Atlantic sturgeon PYSL year class 2020 through 2068.

Annual maintenance dredging will result in the take of 1.8 percent of each shortnose sturgeon PYSL year class from 2019 through 2068.

7.3.2 Clean-Up Dredging Effects to Atlantic Sturgeon Early Life Stages

The habitat targeted for blasting and clean-up dredging (RKM 108-136.8) is made up of exposed bedrock, boulders, gravel, and cobble that are not subject to shoaling and are assumed to be ideal for Atlantic sturgeon spawning and rearing of early life stages. This area is one where numerous studies have reported tracking spawning condition adults and/or reported tracking assumed spawning behaviors (i.e., the Marcus Hook Bar, Eddystone, and Tinicum areas from RKM 125-138)(Simpson 2008; Breece *et al.* 2013; DiJohnson *et al.* 2015).

Blasting will occur outside the time of year when spawning and early life stages will be present; however, you have proposed to conduct clean-up dredging of blasted material over approximately 20 acres between July 1, 2019 and March 15, 2020 (or July 1, 2020 and March 15, 2021). Work conducted between July 1 and September 30 may disrupt spawning activity (July 1 – July 31), eggs and YSL (July 1 – August 31), and PYSL (July 1 – September 30). This work may be complete before spawning begins in 2020. In that case, this work will only impact the 2019 year class. If the work is conducted the following year (the time of the proposed work is dependent on funding and not known at this time) and before the 2021 spawning begins, then the work will impact the 2020 year class.

While PYSL have a better chance of avoiding a mechanical dredge, they may be seeking refuge in the interstitial spaces and therefore, be lethally entrapped. As explained in Section 7.1.2, we make the assumption that Atlantic sturgeon post yolk-sac larvae are evenly distributed temporally (i.e., across the months of May-September) and spatially (within the mainstem Delaware River between the upstream limit of potential spawning grounds (RKM 212) and the salt front (RKM 107.8)). We have estimated an area of 28,436 acres where post yolk-sac larvae may be present between May and September.

No clean-up dredging is proposed in May or June. We assume that an equal amount of PYSL are present in each of the five months when this life stage could be present in the river. The proposed clean-up dredging will occur during three of the five months (July, August and September) or 60 percent of the time when the Atlantic sturgeon PYSL are present. The work will impact approximately 20 acres of the estimated total 28,436 acres where PYSL may be present. Twenty acres represents 0.07 percent (20 / 28,436 = 0.00070) of the total habitat available. Therefore, approximately 0.04 percent (0.6 * 0.0007 = 0.00042) rounded to the nearest hundredth of a percent of the 2019 or possibly 2020 Atlantic sturgeon PYSL year classes may be taken during the clean-up dredging in Reach B.

Eggs are non-mobile and YSL are not yet free swimming, so these lifestages are extremely susceptible to lethal entrapment in a dredge bucket as they have no potential to avoid the dredge. Eggs and yolk-sac larvae occur adjacent to where they were spawned over hard substrates in freshwater, between April and August. While we expect spawning to occur between RKM 125-212, we do not know the number of eggs that are successfully fertilized, nor do we have an estimate of the size of the area where eggs and yolk sac larvae would be present (i.e., the total area of hard bottom substrate suitable for spawning within freshwater from RKM 125-212). Between 2008 and 2010, Delaware's Department of Natural Resources and Environmental Control (DNREC), in partnership with the University of Delaware, Partnership for the Delaware Estuary, and the New Jersey Department of Environmental Protection, carried out substrate imaging in the Delaware Bay and River. DNREC used this imaging to produce a GIS shapefile of substrate for much of the Bay and large portions of the Delaware River up to approximately RKM 132. We clipped this data between RKM 125 and 132, as that area fell within the clean-up dredging area. Within the mapped DNREC data, from RKM 125-132, approximately 26 percent of the river is classified as reef/hardbottom, while the rest is unconsolidated sediments or unknown. We then used ArcGIS Desktop to estimate the total area of the mainstem Delaware River between RKM 125-138 (where we assume spawning occurs) to be 5,792 acres. Extrapolating the DNREC data to the surrounding larger reach of the river where we expect spawning to occur, we estimate that between RKM 125-138, there are 1,507 acres of suitable spawning habitat.

As we do not have benthic survey data to estimate hard bottom substrate in the rest of the river where we expect spawning to occur (i.e., RKM 138-212), for the purposes of this analysis we conservatively assume that the estimated 1,507 acres of suitable spawning habitat between RKM 125-138 is all of the spawning habitat where eggs and YSL occur in the river. This would represent the worst-case scenario. We note throughout this Opinion that we also expect spawning to occur further upstream, which is why we included the full extent of freshwater habitat between RKM 125-212 for purposes of analyzing PYSL; because PYSL may seek refuge in hard bottom substrate and forage in soft substrates, we did not need benthic survey data (i.e., the area of hard vs. soft bottom habitat) from 125-212, as we can assume they are evenly distributed over all of the freshwater area. We only expect eggs and YSL to occur over hard bottom substrate, so the same approach could not be used without an area estimate for hard bottom substrate.

Mechanical rock removal will take place between river kilometer 125.5 and 135.2 from July 1, 2019 to March 15, 2020, or possibly July 1, 2020 and March 15, 2021. Clean-up dredging may co-occur with eggs and YSL from July through August (40% of the time the year class may be present), and will impact approximately 20 acres (20 acres removed/1,507 acres total = 0.0133 or 1.3% of the total area where eggs and YSL may be distributed from RKM 125-138). Therefore, approximately 0.5% (i.e., 0.4 x 0.0133 = 0.0053 or 0.5%) of the 2019 or 2020 egg and YSL year class will be taken from clean-up dredging in Reach B.

7.3.3 Mechanical Dredging Effects on Non-Larval Sturgeon

As noted above, the risk of interactions between sturgeon and mechanical dredges is thought to be highest in areas where large numbers of sturgeon are known to aggregate. This is especially true in areas where sturgeon are overwintering, as overwintering sturgeon may be less responsive to stimuli, which could reduce the potential for a sturgeon to avoid an oncoming dredge bucket. This is the case at Bath Iron Works in Kennebec, Maine, where three recorded captures/entrapments of sturgeon in a mechanical dredge have occurred (one live Atlantic sturgeon, one live shortnose sturgeon, and one dead shortnose).

In total, approximately 175,625,000 cy of material may be removed with a mechanical dredge for the remaining deepening and future maintenance dredging of the Philadelphia to the Sea and Philadelphia to Trenton navigation channels. Some of this dredging may occur during the winter months in Reach B near Marcus Hook, where both species of sturgeon are known to overwinter (ERC 2016, 2017), and Newbold Island (Reach A-B) and Duck Island (Reach B-C), where shortnose sturgeon overwinter.

Because the only confirmed entrapment of Atlantic or shortnose sturgeon in mechanical dredges has been the three sturgeon at Bath Iron Works, it is difficult to predict the number of shortnose or Atlantic sturgeon that are likely to be entrapped during future dredging activities. Based on the available information presented here, entrapment of non-larval sturgeon (i.e., young of year or older) in a mechanical dredge is likely to be rare, and would only occur if dredging occurred within a dense sturgeon aggregation, particularly in overwintering areas. However, because we know that entrapment is possible, we expect that over the duration of the deepening and maintenance dredging project, some entrainment will occur. Therefore, we expect that up to one entrapment/capture of each species of sturgeon may occur every ten years over the 50-year lifespan of this project; therefore, we expect no more than five shortnose sturgeon and five Atlantic sturgeon are likely to be captured during proposed mechanical dredging. Sources of mortality include injuries suffered during contact with the dredge bucket or burial in the dredge scow. Of the three captures of sturgeon with mechanical dredges in the Kennebec River (two shortnose, one Atlantic), one of the shortnose sturgeon was killed. This fish suffered from a large laceration, likely experienced due to contact with the dredge bucket. As the risk of mortality once captured is high, it is reasonable to expect that both the shortnose and Atlantic sturgeon likely to be captured in the dredge bucket could suffer injury or mortality due to contact with the dredge bucket or through suffocation due to burial in the scow.

In summary for non-larval sturgeon, removal of debris with a mechanical dredge (following blasting) and future maintenance dredging through 2068 are likely to result in injury or mortality to no more than 5 Atlantic sturgeon and 5 shortnose sturgeon. The affected shortnose sturgeon could be juveniles or adults. Affected Atlantic sturgeon could be adults, subadults, young of year, or juveniles. Young of year and juveniles will be from the New York Bight DPS. If the Atlantic sturgeon are adults or subadults, they could be from any of the five DPSs. 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 percent; Chesapeake Bay 18 percent; South Atlantic 17 percent; Gulf of Maine 7 percent; and Carolina 0.5 percent.

Any juvenile Atlantic sturgeon entrained during dredging would originate from the Delaware River (New York Bight DPS). We expect that any subadult or adult Atlantic sturgeon entrained during dredging would occur at these frequencies. In the unlikely event that all of the entrapped sturgeon were subadult or adult Atlantic sturgeon, we expect that of the 5, 3 would be from the New York Bight DPS, 1 would from the Chesapeake Bay DPS, and 1 from the South Atlantic DPS. Given the low numbers of the Gulf of Maine DPS and Carolina DPS fish in the action area and the low number of mortalities anticipated, it is extremely unlikely that there will be any mortality of any Gulf of Maine or Carolina DPS Atlantic sturgeon from mechanical dredging.

In most reaches, you have proposed to dredge using a cutterhead or mechanical (or in some case hopper) dredge (see Table 1). Therefore, these 5 shortnose and 5 Atlantic sturgeon would not be in addition to the estimated lethal takes discussed in section 7.1.2 and 7.2.1, but would rather be subtracted from the total estimated lethal take of non-larval sturgeon from hopper dredge or cutterhead entrainment.

7.4 Interactions with Suspended Sediments

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

Wilber *et al.* (2006) reported that elevated total suspended sediment (TSS) concentrations associated with an active beach nourishment site were limited to within 1,312 feet (400 meters) of the discharge pipe in the swash zone (defined as the area of the nearshore that is intermittently covered and uncovered by waves). Another study, conducted 5 years earlier, found that the turbidity plume and elevated TSS levels were expected to be limited to a narrow area of the swash zone up to 1,640 feet (500 meters) down-current from the discharge pipe (Burlas *et al.* 2001). Considering beach nourishment materials consist primarily of coarse sands, plumes from the discharge should settle rapidly (compared to fine sands and silts) and not affect large areas. Based on this and the best available information, TSS concentrations created by beach nourishment operations along an open coastline are expected to be between 34.0-64.0 mg/L; limited to an area approximately 1,640 feet (500 meters) down-current from the discharge pipe; and, settle within several hours after discharge cessation.

7.4.1 Hopper Dredge

Resuspension of fine-grained dredged material during hopper dredging operations is caused by the dragheads as they are pulled through the sediment, turbulence generated by the vessel and its prop wash, and overflow of turbid water during hopper filling operations. During the filling operation, dredged material slurry is often pumped into the hoppers after they have been filled with slurry in order to maximize the amount of solid material in the hopper. The lower density, turbid water at the surface of the filled hoppers overflows and is usually discharged through ports located near the waterline of the dredge. Use of this “overflow” technique results in a larger sediment plume than if no overflow is used. In 1998, a study was done of overflow and nonoverflow hopper dredging using the McFarland hopper dredge (USACE 2013). Monitoring of the sediment plumes was accomplished using a boat-mounted 1,200-kHz Broad-Band Acoustic Doppler Current Profiler (ADCP). The instrument collects velocity vectors in the water column together with backscatter levels to determine the position and relative intensity of the sediment plume. Along with the ADCP, a MicroLite recording instrument with an Optical Backscatterance (OBS) Sensor was towed by the vessel at a depth of 15 ft. The MicroLite recorded data at 0.5-sec intervals. Navigation data for monitoring were obtained by a Starlink differential Global Positioning System (GPS). The GPS monitors the boat position from the starting and ending points along each transect.

Transects were monitored in the test area to obtain the background levels of suspended materials prior to dredging activities. A period of eight minutes following the dredge passing during non-overflow dredging showed the level of suspended material to be returning to background levels. No lateral dispersion of the plume out of the channel was observed during the non-overflow dredging operation. During overflow dredging, a wider transect was performed to determine the lateral extent of the plume. At one hour elapsed time following the end of the overflow dredging operation, the levels of suspended material returned to background conditions. Again, no lateral dispersion of the plume out of the channel area was observed. Overflow dredging is not proposed during deepening or maintenance dredging operations.

Near-bottom plumes caused by hopper dredges may extend approximately 2,300 to 2,400 feet (701-731 meters) downcurrent from the dredge (USACE 1983). TSS concentrations may be as high as several hundred mg/L near the discharge port and as high as several tens of mg/L near the draghead. In a literature review conducted by Anchor Environmental (2003), near-field concentrations ranged from 80.0-475.0 mg/L. TSS and turbidity levels in the near-surface plume usually decrease exponentially with increasing time and distance from the active dredge due to settling and dispersion, quickly reaching ambient concentrations and turbidities. In almost all cases, the majority of re-suspended sediments resettle close to the dredge within one hour, although very fine particles may settle during slack tides only to be re-suspended by ensuing peak ebb or flood currents (Anchor Environmental 2003).

7.4.2 Cutterhead Dredge

Cutterhead dredges use suction to entrain sediment for pumping through a pipeline to a designated discharge site. Production rates vary greatly based on pump capacities and the type (size and rotational speed) of cutter used, as well as distance between the cutterhead and the substrate. Sediments are re-suspended during lateral swinging of the cutterhead as the dredge progresses forward. Modeling results of cutterhead dredging indicated that TSS concentrations above background levels would be present throughout the bottom six feet (1.8 meters) of the water column for a distance of approximately 1,000 feet (305 meters) (USACE 1983). Based on these analyses, elevated suspended sediment levels are expected to be present only within a 1,000 foot (305 meters) radius of the of the cutterhead dredge. TSS concentrations associated with cutterhead dredge sediment plumes typically range from 11.5 to 282.0 mg/L with the highest levels detected adjacent to the cutterhead dredge and concentrations decreasing with greater distance from the dredge (Nightingale and Simenstad 2001).

7.4.3 Mechanical Dredging

Mechanical dredges include many different bucket designs (e.g., clamshell, closed versus open bucket, level-cut bucket) and backhoe dredges, representing a wide range of bucket sizes. TSS concentrations associated with mechanical clamshell bucket dredging operations have been shown to range from 105 mg/L in the middle of the water column to 445 mg/L near the bottom (210 mg/L, depth-averaged) (USACE 2001). Furthermore, a study by Burton (1993) measured TSS concentrations at distances of 500, 1,000, 2,000 and 3,300 feet (152, 305, 610 and 1006 meters) from dredge sites in the Delaware River and were able to detect concentrations between 15 mg/L and 191 mg/L up to 2,000 feet (610 meters) from the dredge site. In support of the New York/New Jersey Harbor Deepening Project, the U.S. Army Corps of Engineers conducted extensive monitoring of mechanical dredge plumes (USACE 2015). The dredge sites included Arthur Kill, Kill Van Kull, Newark Bay, and Upper New York Bay. Although briefly addressed in the report, the effect of currents and tides on the dispersal of suspended sediment were not thoroughly examined or documented. Independent of bucket type or size, plumes dissipated to background levels within 600 feet (183 meters) of the source in the upper water column and 2,400 feet (732 meters) in the lower water column. Based on these studies, elevated suspended sediment concentrations at several hundreds of mg/L above background may be present in the immediate vicinity of the bucket, but would settle rapidly within a 2,400- foot (732 meter) radius of the dredge location.

7.4.4 Dredged Material Disposal

As indicated above, all material removed at Reach B and upper Reach E, and material removed from Reach D (every eight years) will be disposed of at one of the existing confined disposal facilities. When a cutterhead dredge is used, the material is piped directly from the intake to an upland disposal area. The pipe will extend up to three miles, depending on the distance between the dredge site and the disposal site.

Material removed from Reach D (approximately 33,000 cy every 8 years), will be placed on Oakwood Beach. Additionally, sand will be taken from the maintenance dredging (likely Reach E) and used in the Dredge Material Utilization (DMU) study to nourish beaches in 10 different locations in Delaware in New Jersey. 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.

You will dispose dredge material from Reach E at the open water disposal site Buoy 10 in the Delaware Bay. During the discharge of sediment at offshore disposal sites, suspended sediment concentrations have been reported as high as 500.0 mg/L within 250 feet (76 meters) of the disposal vessel and decreasing to background levels (i.e., 15.0-100.0 mg/L depending on location and sea conditions) within 1,000-6,500 feet (305-1981 meters) (ACOE 1983). Multiple characterizations of disposal plume spatial and temporal dynamics have been conducted by the USACE New England District, providing an extensive body of knowledge on all aspects of off-shore disposal (e.g., Fredette and French 2004, SAIC 2005). TSS concentrations near the center of the plume created by the placement of dredged material have been observed to reach near background levels in 35-45 minutes (Battelle 1994 in ACOE and EPA 2010).

7.4.5 Pile Driving and Removal

The installation of steel monopoles for two new range lights, the removal of the existing range light structure, and the removal (by hand) of 20 feet of submerged transmission cable (impacting 3 cubic yards of riverbed substrate) will disturb bottom sediments and may cause a temporary increase in suspended sediment in the action area. Using available information collected from a project in the Hudson River, we expect pile driving activities to produce total suspended sediment (TSS) concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 300 feet (91 meters) of the pile being driven (FHWA 2012). We expect TSS levels caused from hand removal of the transmission cable and removal of the existing range light structure to be equal to or less than the estimate for pile installation.

To install the monopoles, USCG will first install a steel socket or casing into the mudline and underlying bedrock (currently buried under a layer of silt). This casing will act as a cofferdam and contain additional suspended sediments during the installation of the monopoles.

7.4.6 Effects of Turbidity and Suspended Sediments on Sea Turtles and Sturgeon

No information is available on the effects of total suspended solids (TSS) on juvenile and adult sea turtles. Of the effects causing increased levels of TSS discussed above, sea turtles may be exposed to sediment plumes from hopper dredging, cutterhead dredging, beach nourishment, and dredge material disposal at Buoy 10. 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. In all cases where sea turtles would be exposed to increased TSS resulting from proposed activities in this Opinion (mainly Delaware Bay), the area is sufficiently wide for the highly mobile sea turtles to avoid any sediment plume with minor movements. Any effect on sea turtle movements is likely to be too small to be meaningfully measured or detected, and is therefore, insignificant.

Studies of the effects of turbid water 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 TSS levels expected for all of the proposed activities (ranging from 5 mg/L to 500 mg/L) are below those shown to have adverse effects on fish (580 mg/L for the most sensitive species, with 1,000 mg/L more typical; see summary of scientific literature in Burton 1993). With the exception of near field hopper dredge impacts and open water disposal, TSS levels will not reach levels that are toxic to benthic communities (390 mg/L (EPA 1986). We expect elevated levels of TSS to settle out of the water column in about an hour. Mobile prey items will likely be able to uncover themselves from any deposited sediment, while a small percentage of non-mobile prey in the near field range of a hopper may be buried/suffocated. Therefore, effects to sturgeon and sea turtle foraging opportunities from TSS impacts to benthic communities in the navigation channel and at the in-water disposal site, are largely temporary and limited to a small area (i.e., the near-field range where remaining hopper dredge deepening and maintenance dredging of shoals will occur, as well as the footprint of the disposal site). Using the data you have provided, the combined shoaling areas that are subject to frequent maintenance dredging and the areas remaining to be deepened are approximately 2,318 acres. The additional area potentially impacted by near field hopper dredging plumes beyond the area to be dredged would be slightly larger, as turbidity plumes extend away from the dredge footprint. This area is approximately 0.47 percent of the total action area, 0.54 percent of the area in Delaware Bay, and 0.55 percent of the estimated soft substrate below the salt front (RKM 107.8).[19] Effects on sturgeon and sea turtle fitness from reduced prey in these small areas relative to available foraging areas in the rest of the action area are too small to be meaningfully measured or detected, and are insignificant.

TSS is most likely to affect mobile sturgeon (post yolk-sac larvae and older) if a plume causes a barrier to normal behaviors. However, the increase in TSS levels expected are below those shown to have adverse effects on fish, so we expect sturgeon to either swim through the plumes or make small evasive movements to avoid them. Based on the best available information, we will not be able to meaningfully detect, evaluate, or measure the effects of re-suspended sediment on sturgeon resulting from proposed activities when added to baseline conditions. Therefore, effects on mobile sturgeon are insignificant.

The life stages of sturgeon most vulnerable to increased sediment are eggs and non-mobile yolk-sac larvae which are subject to burial and suffocation. As noted above, no shortnose sturgeon eggs or yolk-sac larvae will be exposed to activities that cause increased levels of suspended sediments.

Activities producing suspended sediments may co-occur with Atlantic sturgeon spawning and eggs and yolk-sac larvae from June 1 to August 30 (beach nourishment will not affect spawning/early life stages because of the area where those activities occur). While we do not expect spawning or yolk sac larvae to occur within the shoals or soft substrates targeted for maintenance dredging or deepening, some sediment plumes may extend outside of the dredge footprints into areas of hard bottom substrate where they do occur. We expect TSS levels to be lower than the highest, near field levels, and we expect elevated levels of TSS to return to background levels within approximately one hour. Mechanical dredging to excavate the area for the new light ranges is the only activity to occur outside of the channel. Though the locations are in a silt covered area, there may be hard bottom substrate within 2,400 feet (range of plume from mechanical dredging).

We expect spawning, eggs, and yolk-sac larvae to occur over areas with relatively sheltered

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[19] We used DNREC's 2010 shapefile data "Delaware Bay Upper Shelf Bottom Sediments 2008-2010" to come up with a ratio of soft bottom substrate to hard bottom substrate in the areas they surveyed. We then made the assumption that the data they collected was a representative sample of the substrate in the action area, and extrapolated their findings to the rest of the Delaware Bay and the area below the salt front, as their benthic surveys did not extend past RKM 132.

interstitial spaces amongst exposed bedrock outcrops, boulders, and large cobble. The fact that these areas have maintained exposed outcrops of bedrock, boulders, and cobbles demonstrates that they are in locations where the current and sediment transport keep them clear of soft substrate deposits. We expect the water velocities in these areas to quickly transport any sediment from turbidity producing activities downstream before it settles on spawning habitat or harms fertilized eggs or yolk sac larvae. Therefore, adverse effects to sturgeon spawning habitat, eggs, and yolk-sac larvae are extremely unlikely, and discountable.

7.5 Blasting

Part of the remaining deepening project involves the removal of approximately 25,000 cubic yards of rock pinnacles, covering 20 non-contiguous acres near Marcus Hook, Pennsylvania (RKM 123-136) to deepen the navigation channel in this area. Blasting and removal of rock with a mechanical dredge will occur in areas where bedrock creates areas shallower than 45’. Blasting and rock removal have occurred over three previous winter seasons (December 1, 2015 – March 15, 2016; December 1, 2016 – March 15, 2017; and December 1, 2017 – March 15, 2018). You have proposed a final season from December 1, 2018 – March 15, 2019 or December 1, 2019 to March 15, 2020, depending on funding. During this time of year, the majority of adult shortnose sturgeon are expected to be located at the overwintering area between RKM 190 and 211, which is over 50 river kilometers from the blasting site (RKM 123-136). However, the relocation trawling that occurred in the previous three winters confirm the presence of adult and juvenile shortnose sturgeon and juvenile Atlantic sturgeon in this area during the winter months.

Brundage and O'Herron (2014b) performed a study to determine sturgeon’s preference of rock vs. soft bottom river bottom habitat in the blast area. The researchers deployed an array of Vemco Positioning System (VPS) receivers to track sturgeon movement in the study area, which contained several large rock outcrops, as well as areas of soft sediment (fine-grained silts and clays). The study logged 1,322 movement detections for 17 Atlantic sturgeon, and 13,151 detections were recorded for 63 shortnose sturgeon; 471 (47%) of the Atlantic sturgeon detections were in rock areas, and 532 (53%) were in non-rock areas, while 3,484 (38.8%) of shortnose sturgeon detections were in rock areas, and 5,499 (61.2%) were in non-rock areas. The authors had expected sturgeon to spend the majority of their time in non-rock areas, where there is more habitat for benthic invertebrates that sturgeon would forage on. The substantial number of detections over rock habitat for both species showed that sturgeon may use the rock areas as shelter from currents, while possibly feeding in pockets of soft bottom habitat between the rocks.

Blasting operations will occur up to seven days a week during the December 1 – March 15 blasting period. You estimate that it will take 30 days of using explosives to remove the rock pinnacles. Up to three blasts may occur per day with each blast lasting for approximately 15 seconds. During the previous season, the contractors set off up to six blasts per 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 habitat, the benthic community, and reduced foraging opportunities.

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

- Perform relocation trawling before (November 15-30, 2018 or 2019) and during blasting season (December 1, 2018 – March 15, 2019 or December 1, 2019 – March 15, 2020);
- Monitor sturgeon movement using passive and active acoustic monitoring;
- Use acoustic deterrent system prior to detonation events;
- Minimize the size of explosive charges per delay (time lag during detonation) and the number of days of explosive exposure;
- Subdivide the explosives deployment, using suitable detonating caps with delays or delay connectors for detonation cord, to reduce the seismic energy and total pressure changes induced by the blasting;
- Use decking (explosives separated by delays) in drill holes to reduce total pressure changes;
- Use angular stemming material in the blasting holes above the explosive charges (specifically sized angular rock fragments backfilled in the drill holes to contain the explosive energy and reducing the unwanted effects of a pressure waves emanating from the blast and flyrock);
- Use scare charges for each blast; and,
- Monitor impacts to fish from blasting.

Relocation trawling will be initiated in mid-November 2018, approximately two weeks prior to the anticipated start of blasting operations on December 1, 2018. Initial trawling efforts will attempt to remove as many sturgeon as possible from the blasting area. Trawling will then be performed every other day during blasting to capture relocated sturgeon that move back to the blasting area and sturgeon that recruit into the work area from up or downriver. Data from passive acoustic monitoring (using 13 VEMCO VR2W receivers) will be downloaded at least every five days to track the potential movement of tagged sturgeon in relation to the blasting area. Active acoustic monitoring (using a VEMCO VR100 receiver and an omnidirectional hydrophone) will alert USACE to the presence of tagged sturgeon in the immediate vicinity of the blast location. Blasting will be delayed until detected sturgeon leave. The acoustic deterrent system will be an Applied Acoustic Engineering Ltd. (AAE) “boomer” that will produce a low frequency sound of less than or equal to 204 dB re1µPa peak at a repetition of 20 booms per minute for at least 5 hours prior to each detonation.

Scare charges will be used for each blast. A scare charge is a small charge of explosives detonated immediately prior to a blast for the purpose of scaring aquatic organisms away from the location of an impending blast without producing so much pressure or noise that they could be injured or killed. Two scare charges will be used for each blast. The detonation of the first scare charge will be at 45 seconds prior to the blast, with the second scare charge detonated 30 seconds prior to the blast. Fish may not locate the origin of the first scare charge. The second scare charge allows fish to better locate the source of the charge and maneuver away from the source. Blast pressures will be monitored and upper limits will be imposed on each blast, with pressure remaining below 206 dB at a distance of 500 feet (i.e., ensuring that injurious levels of noise/pressure would only be experienced within 500 feet of the detonation).

7.5.1 Available Information on Effects of Sound Pressure on Fish

Sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005). While there are no data either in terms of hearing sensitivity or structure of the auditory system for Atlantic and shortnose sturgeon, there are data for the closely related lake sturgeon (Lovell *et al.* 2005; Meyer *et al.* 2010), which serve as a good surrogate for Atlantic and shortnose sturgeon when considering acoustic impacts due to the biological similarities among the species. The available data suggest that lake sturgeon can hear sounds from below 100 Hz to 800 Hz (Lovell *et al.* 2005, Meyer *et al.* 2010). However, since these two studies examined responses of the ear and did not examine whether fish would behaviorally respond to sounds, it is hard to determine the level of noise that would trigger a behavioral response (that is, the lowest sound levels that an animal can hear at a particular frequency) using information from these studies. The best available information indicates that Atlantic and shortnose sturgeon are not capable of hearing noise in frequencies above 1,000 Hz (1 kHz) (Popper 2005). Sturgeon are categorized as hearing “generalists” or “non-specialists” (Popper 2005). Sturgeon do not have any specializations, such as a coupling between the swim bladder and inner ear, to enhance their hearing capabilities, which makes these fish less sensitive to sound than hearing specialists. Low-frequency impulsive energies, including pile driving, cause swim bladders to vibrate, which can cause damage to tissues and organs as well as to the swim bladder (Halvorsen *et al.* 2012). Sturgeon have a physostomous (open) swim bladder, meaning there is a connection between the swim bladder and the gut (Halvorsen *et al.* 2012). Fish with physostomous swim bladders, including Atlantic and shortnose sturgeon, are able to expel air, which can diminish tension on the swim bladder and reduce damaging effects during exposure to impulsive sounds. Fish with physostomous swim bladders are expected to be less susceptible to injury from exposure to impulsive sounds, such as pile driving, than fish with physoclistous (no connection to the gut) swim bladders (Halvorsen *et al.* 2012).

If a noise is within a fish’s hearing range and is loud enough to be detected, effects can range from mortality to a minor change in behavior (e.g., startle), with the severity of effects increasing with the loudness and duration of the exposure to the noise (Hastings and Popper 2005). The actual nature of effects and the distance from the source at which they could be experienced will vary and depend on a large number of factors. Factors include fish hearing sensitivity, source level, how the sounds propagate away from the source, and the resultant sound level at the fish, whether the fish stays in the vicinity of the source, the motivation level of the fish, etc.

7.5.1.1 Criteria for Assessing the Potential for Physiological Effects to Sturgeon

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

- Peak Sound Pressure Level (SPL): 206 decibels relative to 1 micro-Pascal (dB re 1 µPa) (206 dB_{Peak}).
- Cumulative Sound Exposure Level (cSEL): 187 decibels relative to 1 micro-Pascal-squared second (dB re 1µPa^2-s) for fishes above 2 grams (0.07 ounces) (187 dBcSEL).
- cSEL: 183 dB re 1µPa^2-s for fishes below 2 grams (0.07 ounces) (183 dBcSEL).

At this time, these criteria represent the best available information on the thresholds at which physiological effects to sturgeon from exposure to impulsive noise, such as pile driving, are likely to occur. It is important to note that physiological effects may range from minor injuries from which individuals are anticipated to completely recover with no impact to fitness, to significant injuries that will lead to death. The severity of injury is related to the distance from the pile being installed and the duration of exposure. The closer the fish is to the source, and the greater the duration of the exposure, the higher likelihood of significant injury.

Since the FHWG criteria were published, two papers relevant to assessing the effects of pile driving noise on fish have been published. Halvorsen *et al.* (2011) documented effects of pile driving sounds (recorded by actual pile driving operations) under simulated free-field acoustic conditions where fish could be exposed to signals that were precisely controlled in terms of number of strikes, strike intensity, and other parameters. The study used Chinook salmon and determined that onset of physiological effects that have the potential of reduced fitness, and thus a potential effect on survival, started at above 210 dB re 1µPa^2-s cSEL. Smaller injuries, such as ruptured capillaries near the fins, which the authors noted were not expected to impact fitness, occurred at lower noise levels.

Halvorsen *et al.* (2012) exposed lake sturgeon to pile driving noise in a laboratory setting. Lake sturgeon were exposed to a series of trials beginning with a cSEL of 216 dB re 1uPa^2-s (derived from 960 pile strikes and 186 dB re 1uPa^2-s sSEL). Following testing, fish were euthanized and examined for external and internal signs of barotrauma. None of the lake sturgeon died as a result of noise exposure. Lake sturgeon exhibited no external injuries in any of the treatments but internal examination revealed injuries consisting of hematomas on the swim bladder, kidney, and intestines (characterized by the authors as “moderate” injuries) and partially deflated swim bladders (characterized by the authors as “minor” injuries). The author concludes that an appropriate cSEL criteria for injury is 207 dB re 1uPa^2-s. Chinook salmon are hearing generalists with physostomous swim bladders. Results from Halvorsen *et al.* (2012a) suggest that the overall response to noise between chinook salmon and lake sturgeon is similar.

It is important to note that both Halvorsen papers (2012a, 2012b) used a response weighted index (RWI) to categorize injuries as mild, moderate, or mortal. Mild injuries (RWI 1) were determined by the authors to be non-life threatening. The authors made their recommendations for noise exposure thresholds at the RWI 2 level and used the mean RWI level for different exposures. We consider even mild injuries to be physiological effects and we are concerned about the potential starting point for physiological effects and not the mean. Therefore, for the purposes of carrying out section 7 consultations, we will use the FHWG criteria to assess the potential physiological effects of noise on Atlantic and shortnose sturgeon and not the criteria recommended by Halvorson *et al.* (2012a, 2012b). Following the FHWG criteria, we will consider the potential for physiological effects upon exposure to impulsive noise of 206 dB_{Peak}. Use of the 187 dBcSEL and 183 dBcSEL threshold (for sturgeon 2 grams or smaller) is a cumulative measure of cumulative impulsive sound (such as impact pile driving) and is not appropriate for blasting. As explained here, physiological effects from noise exposure can range from minor injuries that a fish is expected to completely recover from with no impairment to survival to major injuries that increase the potential for mortality or result in death.

7.5.2 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 or Atlantic 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 or Atlantic 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 and Atlantic 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 the time when the chambers were stocked and the 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 not conducted on Atlantic or shortnose sturgeon, but the nature of the injuries and the optimal distance from the detonations could be applied to blasting activities and shortnose and Atlantic sturgeon. The effects of blasting on shortnose sturgeon have been examined. 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 (1999a), the test blasting consisted of 32-33 blasts (3 rows of 10 to 11 blast holes per row with each hole and row 10 feet apart), about 24 to 28 kg of explosives per hole, stemming each hole with angular rock, and an approximate 25 m/sec delay after each blast. During test blasting, 50 hatchery reared juvenile striped bass and shortnose sturgeon were placed in 0.25" plastic mesh cylinder cages (2 feet in diameter by 3 feet long) 3 feet from the bottom (worst case scenario for blast pressure as confirmed by test blast pressure results) at 35, 70, 140, 280, and 560 feet upstream and downstream of the blast location. For each test, 200 caged shortnose sturgeon were held at a control location 0.5 mi from the test blast area. The caged fish had a mean weight of 55 grams. The cages were enclosed in a 0.6” nylon mesh sock to prevent the escape of any sturgeon if the cage was damaged during blasting. The caging experiments were conducted during a total of seven blasts between December 9, 1998 and January 7, 1999. Three test blasts were conducted with the air curtain in place, and four were conducted without the air curtain. The air curtain (when tested) was 50 feet from the blast. The caged fish were visually inspected for survival just after the blast and after a 24-hour holding period. Mortality rates for control fish were generally low, with 15 fish dead or mortally injured on inspection (out of a total of 1,400 samples). The numbers of injured, dead, and mortally injured sturgeon varied greatly between tests. Of the 500 fish tested during each blast, mortalities (dead or mortally injured) ranged from one to 89 fish. Mortality rates for shortnose sturgeon as compared to the other species tested were low, with the author of the report concluding that this was likely due to the larger size of shortnose sturgeon tested (approximately 30cm average) as compared to the size of the other species (3cm – 20cm).

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

All fish necropsied were within 70 feet of the drill holes (most within 35 feet). These fish 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.

Some fish caged as far as 560 feet away from the blast died or were injured/mortally injured within 24 hours of the blast. Given that some fish in the control study also died, and that none of the fish caged this far away were necropsied, it is impossible to know whether they died of causes unrelated to the blasting experiment.

7.5.3 Effects of Proposed Blasting on Shortnose and Atlantic Sturgeon

During the winter months, we expect most pre-spawning adult shortnose sturgeon to overwinter near Duck and Newbold Island, well upstream of the blasting area (see O'Herron *et al.* 1996). Adult and subadult Atlantic sturgeon leave the river by November and do not return until the spring; therefore, adult and subadult Atlantic sturgeon are unlikely to be present in Marcus Hook in the winter months. Several recent studies, as well as the past two blasting and relocation trawling seasons, have confirmed the use of the Marcus Hook area by juvenile and adult shortnose and juvenile Atlantic sturgeon in the winter months (see ERC 2006, 2016, 2017; Fisher 2011; Brundage and O'Herron 2009, 2014).

Sturgeon appear to be able to withstand some degree of exposure to blasting at a certain distance from the detonation, but it is apparent from the study results outlined above that if sturgeon are close enough to a detonation, the exposure to blasting may injure the species internally and/or externally. Given the discussion of past blasting studies above, we conclude that any sturgeon within 500 feet of the blasts could experience injury or mortality. As noted above, the severity of the impact that blasting has on fish is dependent on several biological and physical variables. Results from previous blasting studies conducted on thirteen species of fish other than shortnose and Atlantic 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, b). 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 percent of fish that appeared to have suffered no injury, sustained injuries from the blasting that it is speculated would have led to their eventual death. If 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 206 dB, consistent with the proposed action would be exposed to noise and pressure levels that could result in avoidance behaviors, temporary stunning, external or internal injury with full recovery, injury with delayed mortality or injury sufficient to cause immediate mortality. Based on the best available information, it is likely that the smaller the fish is and the closer it is to the blast the more significant the injuries would be.

7.5.3.1 <u>Estimating Sturgeon Exposure to Blasting Noise</u>

As explained above, we estimate that in order to be injured or killed, a sturgeon would need to be within 500 feet of the detonation during the 15 second duration of the detonation.

Over the first three blasting seasons, a total of 478 detonation blasts (shots) have occurred (Season 1: 117; Season 2: 211; Season 3: 150). Methods to clear sturgeon from the blast zone (500-foot radius), as well as monitoring whether they have entered it, have shown to be very effective. On multiple occasions, sturgeon were detected using active acoustic monitoring (for acoustically tagged sturgeon). In all of these instances, scare charges were used (as many as five) until the fish left the blast zone. In all, we have attributed nine takes to blasting activities (8 lethal, 1 non-lethal). Post-blast visual surverys continued at least 1,000 ft (305 m) downcurrent of the blast site. No injured sturgeon were recovered immediately following a blast outside of the blast zone (500-foot radius of the blast).

- 2/6/2016: a stunned Atlantic sturgeon was observed on the surface after a blast, but it swam away when observers attempted to capture it with a dip net.
- 3/12/2016: during relocation trawling, an Atlantic sturgeon carcass was incidentally recovered (i.e., it was previously dead). A necropsy report completed August 9, 2016 concluded that the fish may have died from blast related injuries.
- 2/1/2017: two shortnose sturgeon floated to the surface after a blast. One was killed instantly, the other's condition continued to deteriorate and was euthanized the following morning after the sturgeon biologist on site determined it would not survive.
- 3/1/2017: a shortnose sturgeon floated to the surface after a blast (the sturgeon died that night in a holding tank)
- 12/12/17: An injured shortnose sturgeon, gilling occasionally, but not able to maintain equilibrium, was collected after a blast. The biologist tried to revive the sturgeon but it died approximately 1.25 hours after being collected.
- 01/02/2018: An injured Atlantic sturgeon gilling occasionally but not able to maintain equilibrium was collected after a blast. The biologist tried to revive the sturgeon but it died in the holding tank 22 hours after being collected.
- 01/14/2018: An injured shortnose sturgeon was collected after a blast. The sturgeon gilled a few times but died within a few minutes after being collected
- 01/15/2018: An injured shortnose sturgeon with weak gill movements was collected after a blast. The sturgeon died a few minutes after being collected.

Up to three detonations per day will occur potentially for 30 days between December 1, 2018 and March 15, 2019 (or December 1, 2019 and March 15, 2020). You will utilize measures to minimize the potential for blasting to result in the take of sturgeon. You will use a combination of passive and active acoustic monitoring to determine if tagged sturgeon are within a 500-foot radius of the blast site. Active monitoring (with a VEMCO VR100 receiver) will be used to detect sturgeon in the general vicinity of the blasting area, allowing you to determine if sturgeon are likely to move close enough to the blast area to be at risk. If a sturgeon is observed, you will advise the blasting contractor to delay employment of additional scare changes and delay the shot until the sturgeon has moved safely out of the blast zone. Passive monitoring will be performed using 13 Vemco VR2W receivers, and will inform you of the number of sturgeon returning to the relocation trawling site from upland overwintering areas, as well as the rate at which they return. While not all sturgeon in the area are tagged, the tagged fish are expected to be representative of the abundance and distribution of shortnose and Atlantic sturgeon in the area; therefore, relying on the detection of these tagged individuals is a reasonable approach for monitoring the presence of sturgeon in the area.

As noted above, as part of the Brundage and O'Herron (2014a) winter trawling and relocation study, the authors tagged 26 juvenile Atlantic sturgeon and 62 juvenile and adult shortnose sturgeon captured in Marcus Hook (RKM 127-139). These fish were relocated to upriver release locations (30 at Ft. Mifflin (RKM 147), 27 at Torresdale (RKM 176) and 31 at Burlington (RKM 193). Researchers tracked these fish and determined whether they returned to Marcus Hook and if so, how long it took to return. Seventeen (65.4%) of 26 Atlantic sturgeon returned to Marcus Hook, moving back within 0.7-48.4 days (mean of 18.6 days). Forty-nine (79.0%) of 62 shortnose sturgeon returned to Marcus Hook, moving back within 0.4-54.2 days to return (mean of 18.3 days).

During the first blasting season, 63 (80.8%) of the 78 acoustically-tagged Atlantic sturgeon that had been transported upriver returned to the blasting area during the project period (December 1, 2015-March 12, 2016), taking from 1-82 days to return (mean = 11.4 days). Of the 28 acoustically-tagged shortnose sturgeon transported upriver, 4 (14.3%) returned to the blasting area, taking from 6-12 days to do so (mean = 9.2 days). Some of the sturgeon returned to the blasting area extremely quickly, with one Atlantic sturgeon (664 mm TL) swimming approximately 39 miles (63 km) from Roebling to the lower Tinicum Range in one day (ERC 2016).

During the second blasting season, 51 (60.7%) of the 84 acoustically-tagged Atlantic sturgeon that had been transported upriver returned to the blasting area during the project period (November 15, 2016-March 13, 2017), taking from 3-38 days to return (mean = 11.1 days). Of the 45 acoustically-tagged shortnose sturgeon transported upriver, 23 (51.1%) returned to the blasting area, taking from 3-107 days to do so (mean = 25.5 days)(ERC 2017).

During the third blasting season, 52 (68.4%) of the 76 acoustically-tagged Atlantic sturgeon that had been transported upriver returned to the blasting area during the project period (December 1, 2017-March 15, 2018), taking from 3-106 days to return (mean = 23.1 days). Of the 24 acoustically-tagged shortnose sturgeon transported upriver, 12 (50.0%) returned to the blasting area, taking from 4-81 days to do so (mean = 20.9 days).

Based on this, we expect that by carrying out relocation trawling every other day, you will significantly reduce the number of sturgeon in the blasting area during the blasting period. While relocated sturgeon may return to the blast site, relocation trawling is an effective method to temporarily remove sturgeon from the area and reduce the number of sturgeon that could be exposed to the detonations. At the blast site, active acoustic monitoring will alert you to the presence of any tagged sturgeon in the area. In addition, the acoustic deterrent, described in section 7.6.4, may act as a behavioral deterrent to at least some sturgeon and reduce the number of sturgeon in a 500-foot radius around the detonation site.

Given that all of the sturgeon protection measures that were implemented in the previous three winters will be continued for the last season of blasting, and because we expect the distribution and abundance of shortnose and Atlantic sturgeon in the blasting area will be comparable in the 2018-2019 season as it was in the previous three blasting seasons, we expect that a similar number of sturgeon would be exposed to blasting that results in injury or mortality. As noted above, two sturgeon were killed during blasting in 2015-2016, three were killed during blasting in 2016-2017, and four were killed during blasting in 2017-2018. A smaller amount of blasting (20 acres) than what occurred in the previous three seasons (128 acres) is scheduled for 2018-2019. Water temperatures, flow, and other environmental factors affect movements of sturgeon in and out of the blasting area. Therefore, it is not possible to predict a direct relationship between the amount of blasting and expected number of sturgeon that will be killed during the blasting. To be conservative, we expect that as many as five sturgeon (shortnose or Atlantic) will be killed during the blasting of the rock pinnacles. Based on the life stages that occur in the area and the previous mortalities, the shortnose sturgeon killed could be young of year, juvenile, or adults; the Atlantic sturgeon will likely be young of year or juveniles from the NYB DPS.

Outside of the 500-foot zone, we do not expect any adverse effects to sturgeon from blasting. Levels of noise from the blast may exceed the behavioral threshold for sturgeon (150 dB RMS) beyond 500 feet. However, the river is over 4,500 feet wide where blasting will occur, so we expect sturgeon to have sufficient space to maneuver away from the blasting area. Also, the noise from blasting will be extremely short in duration. Any effects on sturgeon as they move away from the blasting noise will be short term and too small to be meaningfully measured or detected, and therefore, insignificant.

7.6 Relocation Trawling

As explained above, the relocation trawling will occur in the area where blasting is planned. For two weeks prior to the commencement of the blasting season (we expect trawling to begin November 15, 2018 or 2019), as well as every other day (weather permitting) during the blasting season, you will trawl intensively in the Marcus Hook blasting area in an attempt to remove as many Atlantic and shortnose sturgeon as possible from the 500-foot radius of any detonation. It will not be possible to trawl within the immediate vicinity of a blasting site once the charges are being set. Trawling procedures were designed to be consistent with our recommendations for sturgeon research (see Damon-Randall *et al.* 2010 and Kahn and Mohead 2010).

7.6.1 Capture

The number of sturgeon caught per haul and per day varied among the previous seasons, including the feasibility study (Table 16 and Table 17). Despite fewer days of trawling, the total number of sturgeon, as well as the capture rate (per trawl), were substantially higher in the 2017/18 season than in the previous two seasons of relocation trawling. During all three blasting seasons, the total number of Atlantic sturgeon and shortnose sturgeon captured during the pre-blasting trawls were lower than the number caught during the support trawls reflecting the difference in effort (i.e. total number of trawl hauls) between the two.

However, the number of sturgeon caught per haul varied between the pre-blasting and the blasting support trawls (Table 16 and Table 17). Few sturgeon were captured in the pre-blast trawling during the first season (2015/16) and more sturgeon were caught per haul during the support trawling than during the pre-blasting trawling. In contrast, during the two last blasting seasons (2016/17 and 2016/18), the average number of sturgeon captured per haul was lower during the support trawling than during the pre-blasting trawling. The lower number caught per haul during the support trawling indicates that the 14 days of the pre-blast trawling efficiently reduces the number of sturgeon present when blasting starts. Based on the differences in catch between the pre-blast and the support trawling, we will calculate the estimated number of sturgeon caught in the coming blasting season separately for the pre-blast and the support trawling.

Table 16. Number of Atlantic (ANS) and shortnose (SNS) sturgeon captured during the pilot study and the pre-blasting trawling. The table shows total number of days of trawling, total number of hauls, average number of hauls per day, percent shortnose of the total catch, and the average number of sturgeon per haul for each season.

Season	# days	Haul #	Haul/ Day	ANS #	SNS #	Tot STG	% SNS	ANS/ haul	SNS/ Haul	STG/ haul
2014 pilot	*9*	*35*	*3. 89*	*37*	*67*	*104*	*64.4*	*1.06*	*1.91*	*2.97*
2015/16	14	105	7.50	64	26	90	28.9	0.61	0.25	0.86
2016/17	14	129	9.21	184	73	257	28.4	1.43	0.57	1.99
2017/18	14	101	7.21	1002	53	1055	5.0	9.92	0.52	10.45

Table 17. Number of Atlantic (ANS) and shortnose (SNS) sturgeon captured during support trawling. The table shows total number of days of trawling, total number of hauls, average number of hauls per day, percent shortnose of the total catch, and the average number of sturgeon per haul for each season.

Season	# days	Haul #	Haul/ Day	ANS #	SNS #	Tot STG	% SNS	ANS/ Haul	SNS/ haul	STG/ haul
2015/16	43	212	4.93	333	85	418	20.3	1.57	0.40	1.97
2016/17	52	502	9.65	207	227	434	52.3	0.41	0.45	0.87
2017/18	38	275	7.24	1504	486	1990	24.4	5.46	1.76	7.24

Because trawling will be conducted in the same reach of the river as in previous seasons, we expect that sturgeon distribution, abundance and behavior will be similar in 2018-2019 (or 2019-2020) as during the previous winters. Further, since the number of sturgeon caught per season has varied substantially among seasons, and to be conservative, we have used the 2017/2018 catch rate to calculate the expected catch of sturgeon.

The proposed pre-blast relocation trawling effort (2018-2019 or 2019-2020) will be similar (14 days during the end of November) to what occurred in 2017-2018. Based on this, we expect that the number of sturgeon caught during the proposed pre-blasting relocation trawling to be similar to the 2017/2018 season. Thus, we expect 1,055 sturgeon to be caught during the pre-blasting relocation trawling.

The total number of proposed blasting support trawls (about a total of 109 trawl hauls) will be fewer than in the previous three blasting seasons because blasting effort (i.e. number of days of blasting) will be less. We expect about 15 days of relocation trawls will be conducted during the blasting season as blasting will occur over a 30-day period with trawls occurring every other day. An average of 7.2 sturgeon were caught per haul during the 2017/18 season with about 7.2 hauls per day over 38 days of trawling. Thus, we expect that the proposed blasting support trawling will result in the capture of 786 sturgeon (7.24 sturgeon/haul * 7.24 hauls/day * 15 days of trawling).

Adding the numbers of sturgeon that we expect to be caught during the pre-blasting and the blasting support trawls, a total of 1,841 will be caught in the relocation trawls during the 2018—2019 (or 2019—2020) blasting.

As can be seen in Table 16 and Table 17, there was no consistent proportion of shortnose sturgeon caught across seasons for pre-blast trawls, support trawls, or for the two combined. The percent of shortnose sturgeon caught in various trawls ranged from 5 percent (2017 pre-blast) to 64 percent (feasibility study). Thus, it is not possible to predict the number caught of each of the two species but we do not expect the proportion of shortnose sturgeon caught during relocation trawling to exceed 50 percent of the total 1,841 sturgeon. The shortnose sturgeon could be young of year, juvenile, or adults; the Atlantic sturgeon will likely be young of year or juveniles. All young of the year and juvenile Atlantic sturgeon will be from the NYB DPS.

7.6.1.1 Capture Mortality

Atlantic sturgeon captured in trawl gear as bycatch of commercial fishing operations have a mortality rate of approximately 5 percent (based on information in the NEFOP database). Short tow duration and careful handling of any sturgeon once on deck is likely to result in a very low potential for mortality. We reviewed records from eight long-term trawl surveys carried out by Northeast States (ME/NH, MA, CT, NJ, DE, VA) that capture sturgeon, including two surveys that occur in the Delaware River. These surveys have collectively operated for thousands of hours with some dating back as far as the 1960s. A total of nearly 900 Atlantic and shortnose sturgeon have been captured during these surveys, with no recorded injuries or mortalities. All of these surveys operate with tow times of thirty minutes or less. Similarly, the NEFSC surveys have recorded the capture of 110 Atlantic sturgeon since 1972. The NEAMAP survey has captured 102 Atlantic sturgeon since 2007. To date, there have been no recorded injuries or mortalities. In the Hudson River, a trawl survey that incidentally captures shortnose and Atlantic sturgeon has been ongoing since the late 1970s. To date, no injuries or mortalities of any sturgeon have been recorded.

During the Brundage and O'Herron (2014a) trawling relocation study, two small sturgeon (one Atlantic 28.2 cm TL; one shortnose 30.6 cm TL) were injured during trawling. The Atlantic suffered a broken primary ray on its right pectoral fin and injury to its pectoral girdle, while the shortnose also had an injury to its pectoral girdle. Both injuries were likely caused by debris in the trawl net. Both were released but had difficulty maintaining equilibrium and may not have survived. Therefore, two of the 104 sturgeon captured in this study were injured (1.9%).

A modified net was employed for the first two blasting seasons. Thus, our 2015 Opinion did not consider that sturgeon would be killed during relocation trawling, as we expected gear modifications to eliminate the risk of mortality from debris. However, on December 2, 2015, two young of year Atlantic sturgeon were killed when a large stump entered the trawl net and crushed them. On December 14, 2015, an Atlantic sturgeon captured during relocation trawling was injured by a catfish spine while in the net. It had normal opercular movements, but had difficulty with buoyancy, which effected its swimming. The injured sturgeon was showing signs of recovery when it was released, but we assume that its decreased fitness may have led to a mortality. No mortalities were documented in the 2016-2017 relocation trawling. The 2017-2018 relocation trawling again resulted in the mortality of two sturgeon. The pre-blast relocation trawling conducted in November 2017 took in large woody debris that crushed one small Atlantic sturgeon on November 22. Following this incident, the contractor installed debris "catcher" lines where the body of the trawl net transitioned to the cod end to prevent large debris from working down into the cod end. Nevertheless, on November 28, another small Atlantic sturgeon was killed by large woody debris in the trawl. Additional catcher lines spaced closer together were rigged after the second mortality. With this system, large debris was removed from the net through an approximately 2 m slit in the net webbing that was laced closed during fishing. The more closely spaced catcher lines were effective in trapping large tires and woody debris and no additional mortalities occurred for the reminder of the blasting season, although the catcher lines increased the time required to clear the debris from the net.

Handling and transport of sturgeon can also result in sturgeon being killed. As part of the relocation pilot study (Brundage and O'Herron 2014a), a shortnose sturgeon (507 mm FL, 604 mm TL, 1.08 kg) died when it was inadvertently left in the transport tank on the night of February 25, 2014. This accident was related to adverse and deteriorating weather conditions (significant wind and waves, heavy icing on the deck of the boat) that night and was not related to the transportation methodology itself. Additional procedures have since been implemented to ensure that this does not happen again. Handling and transport did not result in sturgeon being killed during the three post-pilot blasting seasons.

While a total reduction in effort is proposed for the fourth season of blasting and relocation trawling, to be conservative, we consider that the trawling and relocation will result in a similar number of injuries and mortalities as observed in previous seasons. This is because previous experiences show that the circumstances that cause injury or mortality can be variable and unpredictable, mortality occurred despite the assumption that it would not happen, and because of the possibility of gear failure or malfunction.

As noted above, there was no mortality in 2016-2017 (691 total sturgeon relocated), three mortalities occurred in 2015-2016 (886 total sturgeon relocated), and two mortalities occurred in 2017-2018 (3,045 total sturgeon relocated). Based on this information, we expect as many as three sturgeon to be killed during relocation trawling (November 15, 2018 or 2019 – March 15, 2019 or 2020). The shortnose sturgeon could be young of year, juvenile, or adults; the Atlantic sturgeon will likely be young of year or juveniles from the NYB DPS.

7.6.2 Effects of Tagging

Placing tags on or in the fish breach the skin of the fish. This can result in infections and injuries that may not heal. Radio tag implants can reduce a fish's swimming performance.

7.6.2.1 Passive Integrated Transponder (PIT) Tags

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

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

7.6.2.2 Floy Tags

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

Smith *et al.* (1990) compared the effectiveness of dart tags with nylon T-bars, anchor tags, and Carlin tags in shortnose and Atlantic sturgeon. Carlin tags applied at the dorsal fin and anchor tags in the abdomen showed the best retention. It was noted however, that anchor tags resulted in lesions and eventual breakdown of the body wall if fish entered brackish water prior to their wounds healing. Collins *et al.* (2002) found no significant difference in healing rates (with T-bar tags) between fish tagged in freshwater or brackish water. Clugston (1996) also looked at T-bar anchor tags placed at the base of the pectoral fins and found that beyond two years, retention rates were about 60 percent. Collins *et al.* (2002) compared T-bar tags inserted near the dorsal fin, T-anchor tags implanted abdominally, dart tags attached near the dorsal fin, and disk anchor tags implanted abdominally. They found that for the long-term, T-bar anchor tags were most effective (92%), but also noted that all of the insertion points healed slowly or not at all, and, in many cases, minor lesions developed.

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

Injection of Floy tags into the dorsal musculature may result in raw sores that may enlarge over time with tag movement (Collins *et al.* 2002, Guy *et al.* 1996). Beyond the insertion site, it is unknown what effects on the fish the attachment of Floy tags may have. We know of no long-term studies evaluating the effect of these tags on the growth or mortality of tagged shortnose or Atlantic sturgeon. Anecdotal evidence recounted in NOAA's protocol (Moser *et al.* 2000) suggests that Floy tags have little impact on the fish because a number of shortnose were recovered about 10-years after tagging although no data are available to evaluate any effects on growth rate. Studies on other species suggest that the long-term effect of injecting anchor tags into the muscle may be variable. Researchers have observed reduced growth rates in lemon sharks and northern pike from tagging, whereas studies of largemouth bass did not depict changes in growth rates (Manire and Gruber 1991, Scheirer and Coble 1991, Tranquilli and Childers 1982).

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

7.6.2.3 Internal Sonic Transmitters

Up to 100 individual sturgeon (combination of shortnose and Atlantic) will be tagged with Vemco sonic transmitter devices (model V7, V9, V13 or V16). The weight of tags will be limited to no more than 2 percent of a given fish's body weight. Sonic transmitters will be attached via incision, implantation, and suturing. Active and passive tracking would follow transmitter attachment.

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

Survival rates after implanting transmitters in shortnose sturgeon are high. Collins *et al.* (2002) evaluated four methods of radio transmitter attachment on shortnose sturgeon. They found 100 percent survival and retention over their study period for ventral implantation of a transmitter with internally-coiled antenna. Their necropsies indicated there were no effects on internal organs. Given the biological similarities between shortnose and Atlantic sturgeon, we expect similar results for Atlantic sturgeon implanted with transmitters.

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

Growth rates after transmitter implantation are reported to decrease for steelhead trout. Welch *et al.* (2007) report results from a study to examine the retention of surgically-implanted dummy acoustic tags over a 7 month period in steelhead trout pre-smolts and the effects of implantation on growth and survival. Although there was some influence in growth to week 12, survival was high for animals > 13 cm FL. In the following 16 week period, growth of surgically implanted pre-smolts was the same as the control population and there was little tag loss from mortality or shedding. By 14 cm FL, combined rates of tag loss (mortality plus shedding) for surgically implanted tags dropped to < 15% and growth following surgery was close to that of the controls.

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

Implanted transmitters could affect fish swimming performance. Thorstad *et al.* (2000) studied the effects of telemetry transmitters on swimming performance of adult farmed Atlantic salmon. These researchers found that swimming performance and blood physiology of adult Atlantic salmon (1021-2338 g, total body length 45-59 cm) were not affected when equipped with external or implanted telemetry transmitters compared with untagged controls. There was no difference in endurance among untagged salmon, salmon with small external transmitters, large external transmitters and small body-implanted transmitters at any swimming speed. Authors cautioned that results of wild versus farmed salmon may be different (Peake *et al.* 1997). However, a similar study using sea-ranched Atlantic salmon found no difference in endurance, similar to the farmed salmon study (Thorstad *et al.* 2000). Adams *et al.* (1993) demonstrated that juvenile Chinook salmon < 120 mm FL with either gastrically or surgically implanted transmitters had significantly lower critical swimming speeds when compared to control fish 1 day after tagging as well as at 19-23 days after tagging; however, in this study tags were more than 4.6 percent of the fish’s body weight and the authors concluded that limiting tag size would minimize the potential for impacts to swimming performance

Since implantation requires surgery, we have considered the ability of wounds to heal successfully. Several factors can impede wound healing in fish including secondary infection and inflammation. Fish epidermal cells at all levels are capable of mitotic division, and during wound healing there is a loss of the intracellular attachments and cells migrate rapidly to cover the defect and provide some waterproof integrity (Wildgoose 2000). This leads to a reduction in the thickness of the surrounding epidermis and produces a thin layer of epidermis at least one cell thick over the wound; however, the process can be inhibited by infection (Wildgoose 2000). Thorstad *et al.* (2000) reports that when examined between 6 and 20 days after tagging, incisions were not fully-healed in 13 of the 126 Atlantic salmon examined. However, the authors speculate that slow healing could be due to the storage of a large number of tagged fish in the same tanks and repeated netting and handling of the fish after tagging. Juvenile largemouth bass implanted with microradio transmitters exhibited short-term (5 days) inflammation around the incision and suture insertion points for both non-absorbable braided silk and non-absorbable polypropylene monofilament, but in the longer term (20 days) almost all sutures were shed and the incisions were completely healed (Cooke *et al.* 2003). Chapman and Park (2005) examined suture healing following a gonad biopsy of Gulf of Mexico sturgeon and found both the absorbable and nonabsorbable sutures to effectively sew the skin after biopsy with all sturgeons surviving surgery and incisions healing 30 days after the intervention.

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

Coating the transmitters has been suggested to vary the rate of expulsion. It has been hypothesized that paraffin coating of the transmitter increases expulsion rate (Chisholm and Hubert 1985). Moser and Ross (1995) reported that retention of surgically implanted tags could be improved for Atlantic sturgeon when the transmitters were coated with a biologically inert polymer, Dupont Sylastic. Additionally, Kieffer and Kynard (2012) report that tag rejection internally is reduced by coating tags with an inert elastomer and by anchoring tags to the bodywall with internal sutures. Kieffer and Kynard's fish retained tags for their operational life, and in most cases, lasted much longer (mean, 1,370.7 days).

We expect that shortnose and Atlantic sturgeon exposed to internal sonic transmitter implantation would respond in a manner similar to the available information presented above. Survival rates are expected to be high with no ill effects on internal organs expected as a result of the transmitters. We do not expect mortality to occur as a result of this procedure, although a few tagged fish from studies reported above have disappeared and their fate was unknown. We expect that growth rates or swimming performance could be affected and that expulsion of the transmitter could occur, although, there have been no mortalities or infections reported to be associated with expulsion. We expect that the surgical wound would heal normally, but acknowledge that adverse effects of these proposed tagging procedures could include pain, handling discomfort, hemorrhage at the site of incision, risk of infection from surgery, affected swimming ability, and/or abandonment of spawning runs. The research methodologies will minimize these risks, as choice of surgical procedure, fish size, morphology, behavior and environmental conditions can affect the success of telemetry transmitter implantation in fish (Jepsen *et al.* 2002).

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

7.6.2.4 Anesthetic

Prior to surgery, sturgeon will be anesthetized with buffered tricaine methane sulfonate (MS-222). Concentrations of MS-222 of 50 mg/L will be used to sedate sturgeon from induction to a maintenance state of surgical anesthesia for implantation surgery (total loss of equilibrium, no reaction to touch stimuli, cessation of movement, except for opercula movement).
Because MS-222 is acidic and poorly absorbed, resulting in a prolonged induction time, Sodium bicarbonate (NaHCO3) would be used to buffer the water to a neutral pH.

MS-222 is a recommended anesthetic for sturgeon research when used at correct concentrations (Moser *et al.* 2000, USFWS 2008). It is rapidly absorbed through the gills and its mode of action is to prevent the generation and conduction of nerve impulses with direct actions on the central nervous system and cardiovascular system. Lower doses tranquilize and sedate fish while higher doses fully anesthetize them (Taylor and Roberts 1999). In 1997, the U.S. Food and Drug Administration (FDA) approved MS-222 for use in aquaculture as a sedative and anesthetic in food fish (FDA 2002).

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

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

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

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

7.6.3 Combined Effects of Sturgeon Capture, Handling, and Relocation

You propose to capture sturgeon within the blasting area by trawling. Relocation trawling involves the trawl net enclosing around the sturgeon followed by the lifting of the trawl net with the fish out of the water. The net is then placed onto the deck of the vessel where the fish will be taken out of the net and transferred to water-filled holding tanks. The sturgeon will then be lifted out of the holding tanks for measurements and the insertion of tags. Once everything is completed, the sturgeon is transferred back to the holding tanks where they will remain until they are transported by boat upriver to the release site. Assuming that sturgeon are retained until the end of the day’s trawling activities and that daily catches will be similar to the previous season, a median of 52 (minimum=11, maximum=160) sturgeon will be placed in the tanks and hauled upstream. The release site is approximately 61 km upstream though sturgeon may be released closer to the capture location when icing of the river occurs (ERC 2018). Assuming that the vessel moves at 10 knots (~1.9 km/h), transport to the release location will take three hours or less.

Fish perceive capture and handling as a threatening situation. The general physiological response of fish to threatening situations, as with all vertebrates, is referred to as stress. Thus, capture, handling, and transport of fish can cause significant stress responses in fish. Severe stress can increase the susceptibility to infections and diseases, result in exhaustion, cause osmoregulation imbalance, and affect egg development (Barton 2002).

Relocation of sturgeon involves transporting the fish from their current home range and releasing them in a new location. Release in unfamiliar locations can cause stress and may not meet the biological needs of the fish. If the new location does not meet the biological needs of the fish, then it may move to new locations providing suitable habitat (including its original location). Movement increases energy consumption and exposes fish to predators.

All relocation will occur during the period from December 1 through March 15. Winter poses special challenges on fish and is generally a seasonal bottleneck for survival. For instance, low temperatures may reduce critical swimming speed (Deslauriers and Kieffer 2012), while high flows increase the demand on the fish's maneuverability and performance. Many fish do not feed or feed at a reduced rate during the winter and high water flow increases their energy demands. Thus, many fish reduce their movements and seek winter refuge. Given this, relocation during the winter may exacerbate effects caused by handling and relocation

Each of the activities – capture, handling, transport, and relocation – alone may cause stress responses in sturgeon. Together these activities may increase the intensity of a fish's stressor responses and result in cumulative or synergistic effects that reduces growth, survival, and/or fecundity (Wedemeyer *et al.* 1990). Further, recapture of a fish may increase the probability and intensity of effects.

7.6.3.1 Capture, Handling, and Transport Stress

A fish exposed to a perceived or real threat responds with stress. Stress is an energy-demanding process, and the animal has to mobilize energy substrates to metabolically cope with stress. Stress from a physiological perspective may be understood as the non-specific response of the body to any demand put upon it such that it causes an extension of a physiological state beyond the normal resting state (Selye 1973). However, stress is not necessarily detrimental to the fish but rather an adaptive compensatory response enabling the fish to cope with stressors to maintain its normal state or homeostasis (Barton 2002, Wedemeyer *et al.* 1990). A fish will compensate behaviorally to stressor exposure by avoiding the stressor or modifying its behavior to mitigate exposure. Once the stressor is removed, the fish will return to a pre-stress state and normal activities. However, if a fish cannot avoid or behaviorally mitigate for a stressor and the stress is severe or long lasting, then compensation may not be possible and the fish's stress response results in negative effects (Wedemeyer *et al.* 1990). Negative effects include exhaustion, reduced gamete quality, osmoregulatory disturbance, increased susceptibility to infections and diseases, and changes in how the animal senses and responds to its environment (Barton 2002, Iwama 1998, Olla *et al.* 1995, Schreck and Tort 2016, Wedemeyer *et al.* 1990). Ultimately, negative effects may lead to reduced growth, survival, and/or fecundity. Therefore, here we define stress responses beyond the normal range such that it may cause reductions in performance or fitness.

Stress response is commonly divided into three successive levels of biological organization (Barton 2002, Sopinka *et al.* 2016, Wedemeyer *et al.* 1990). The primary response involves the initial neuroendocrine/endocrine (i.e., hormonal) responses when exposed to a stressor. Thus, the testing of cortisol blood levels and the rate at which they return to their pre-stress state is commonly used to test the degree of the stress experienced by fish. The secondary physiological responses are responses that occur as the hormones bind to cellular receptors and thereby alter the physiological responses such as metabolism. Thus, changes to blood glucose, red blood cells, lactate, blood pH, and hydromineral balance (osmoregulation), are often measured as secondary indicators of stress responses. The tertiary response refers to aspects of the performance by the whole animal. This includes changes in oxygen consumption, respiration, vitality, growth, weight, disease resistance, and, ultimately, survival and reproduction. Any of these may be used as a tertiary indicator of stress.

In unconfined natural conditions, fish respond with flight or behavioral avoidance when exposed to stressors, e.g., predators or strong water currents. However, the proposed catch and relocation will expose sturgeon to several hours of stressors that cannot be escaped. Further, the fish will be exposed to multiple stressors and this can result in cumulative effects in fish. Based on this, we find it reasonable to conclude that these activities individually and overall result in the sturgeon experiencing an intensity and duration of stressor exposure that significantly exceeds what it would experience during normal conditions. The duration also exceeds exposure to stressors from many other anthropogenic activities such as by-catch in fisheries where fish are quickly released back into the water, sound from pile driving, or suspended sediment from dredging. Further, a small number (3.5 percent of Atlantic sturgeon and about 1 percent of shortnose sturgeon) of the sturgeon caught during the three first seasons were caught and relocated multiple times and thus, experienced this type of stress more than once.

Studies show that exposure of sturgeon to various capture and handling related stressors result in significant physiological stress. However, the hormonal and metabolic responses to stressors in sturgeon (cohndronstean fishes) are generally low compared to teleost fishes (Baker *et al.* 2005, Kieffer *et al.* 2001).

Primary Responses

Cortisol is released by the kidney and has gluconeogenic (triggers release of glucose), immunosuppressive, and osmorregulatory functions. Consistent presence of cortisol can result in energy depletion and reduced growth, metabolic exhaustion, and increased disease incidents. Cortisol levels in fish following exposure to a stressor typically range from 30 to 300 mg/l (Baker *et al.* 2005, Barton 2002, Iwama 1998).

Capture

Sturgeon captured in fishing gear are expected to respond with flight behaviors and increased activity. Cortisol level response to five minutes of forced exercise at about 15 degrees Celsius water temperature were 8 ng/ml (from 1.7 ng/ml at resting) in Atlantic sturgeon and 127 ng/ml (from 8.5 ng/ml at resting) in shortnose sturgeon (Baker *et al.* 2005). Peak response occurred one hour after the test. White sturgeon (*Acipenser transmontanus*) exposed to forced activity for 15 minutes had elevated cortisol compared to the control but sturgeon exposed to five or ten minutes of forced exercise did not have elevated cortisol levels (McLean et al 2016). However, cortisol was measured immediately after treatment and the study may not have captured the response in cortisol levels as peak cortisol levels may occur sometime after exposure to a stressor. Water temperature also affected the response level (51.5 ng/ml at 6.6°C water temperature and 73.2 ng/ml at 15.3°C water temperature) in the white sturgeon. In green sturgeon (*Acipenser medirostris*), the peak cortisol response to stressor exposure was delayed at a lower water temperature compared to a higher temperature (Lankford *et al.* 2003).

Handling

Sturgeon are exposed to air when the net is retrieved, when they are removed from the net, and during measuring and tagging. Air exposure is experienced by fish as exposure to hypoxia and stress. Green sturgeon response to 60 seconds of air exposure was temperature dependent with fish held at 19-degree Celsius water temperature having a faster response (56.7 ng/ml peak after 10 min.) than what was seen in the fish held at 11 degrees Celsius (50.3 ng/ml peak after 30 min.) (Lankford *et al.* 2003). However, the peak cortisol responses were not significantly different between the two temperatures. The cortisol levels in green sturgeon held at 11 degrees Celsius also took a longer time to return to resting levels but cortisol levels had stabilized to resting levels within two hours in both groups. The longer time to reach the peak cortisol level at the lower temperature observed in green sturgeon may explanin the observed difference in cortisol response at the two different water temperatures for white sturgeon as the cortisol levels in that study were measured in blood taken at similar times following the stressor exposure (McLean *et al.* 2016). For yearling pallid sturgeon (*Scaphirhynchus albus*) and pallid-shovelnose sturgeon (*S. albus* X *platorunchus*) hybrids, a 30-second removal out of the water (meant to mimicking handling) resulted in a small but insignificant increase in cortisol levels (Barton *et al.* 2000). Average plasmas cortisol levels in pallid sturgeon held for 0.5 hour in water with low DO concentration (2 mg/l) was 20.3 ng/ml as compared to average levels of 5.1 before stressor exposure. Cortisol levels returned to pre-stress levels after 2.5 hours (Nelson and Small 2014).

Transportation

Sturgeon respond to transportation with a significant increase in cortisol levels. Cortisol levels (average resting level: 8.6 ng/ml) in cultured white sturgeon that were transported in holding tanks by car for an hour increased after only 15 minutes, reached a peak of 33.4 ng/mL at the end of transportation, and fell to pre-transport levels after three hours (Belanger *et al.* 2001). A 7.5-hour truck transport of hatchery raised juvenile pallid sturgeon and a pallid-shovelnose hybrid resulted in only a small though significant increase (1.16±0.21 SE ng/mL before to 4.70±0.42 SE ng/mL after transport) in cortisol levels (Barton *et al.* 2000). Holding *Scaphirhynchus* sturgeon in crowded conditions increased the fish's cortisol levels (from ~3 ng/ml to >12 ng/ml), the response increased with the time held (up to 6 hours) in a crowded condition, and the cortisol remained elevated at least 30 minutes after the removal of the crowded condition (Barton *et al.* 2000, Nelson and Small 2014). Baker *et al.* (2005) found that Atlantic sturgeon and shortnose sturgeon confined in dark boxes had low cortisol levels (i.e. mild response), which contrasted with responses observed in many teleost fishes.

Cortisol levels have also been measured in the field. Atlantic sturgeon captured during a one-hour otter trawl effort in the inner Bay of Fundy, Nova Scotia, with subsequent handling (up to 30 minutes from on-deck to sampling of blood) had low cortisol levels (measured cortisol between 5 and 6 ng/mL: measured cortisol between 5 and 6 ng/mL: measured cortisol between 5 and 6 ng/mL: measured cortisol between 5 and 6 ng/mL: Beardsall *et al.* 2013). In wild adult lake sturgeon (*Acipenser fulvescens*), cortisol levels were high (49.5±4.4 SE ng/mL) following their capture in gill nets, transport to the handling station, and the placement of tags and fell to 2.4±0.2 SE ng/mL after three days in low density holding tanks (Baker *et al.* 2005).

These and other studies shows that plasma cortisol response to stress varies depending on the stressor and species. Minor stressors result in only low increase in cortisol but severe stressors can cause a significant increase plasma cortisol. The studies do show that cortisol response is delayed and that levels increase with the stressor exposure duration. Low temperatures may delay the cortisol response and the return to a pre-stress state.

Secondary Responses

Elevation of plasma glucose is followed by the elevation of corticosteroids (e.g., cortisol) and catecholamines (adrenalin). Glucose is an energy source for cell and muscle activity and stress-induced increase in blood glucose is and adaptive response to provide an energy source for fish during stressful conditions. However, mobilization of glucose as a response to stress can deplete glycogen reserves needed by the fish for growth and can result in metabolic exhaustion. As a reference, salmonids have a typical plasma glucose concentration above 5 mmol/l with stress response typically above 10 mmol/l. However, sturgeon exposed to capture stressors respond with low or no increase in plasma glucose levels (Baker *et al.* 2005, Beardsall *et al.* 2013, Kieffer *et al.* 2001, Struthers *et al.* 2018). Difference in plasma glucose levels (average between 3 and 3.5 mmol//l) between Atlantic sturgeon caught in one-hour otter trawls and Atlantic sturgeon caught in weirs that fish entered voluntarily were insignificant (Beardsall *et al.* 2013). Struthers *et al.* (2018) found that large shortnose sturgeon were more likely to have elevated plasma glucose than smaller sized individuals. Sturgeon also differ from teleost fishes in that cortisol can promote the mobilization of glucose (i.e., energy reserves) in fish but studies on sturgeon have not found a clear relationship between cortisol and glucose levels (Baker *et al.* 2005).

Fish caught in fishing gear are expected to engage in forced swimming activities to escape that results in immediate use of energy and increased oxygen demand. The integrity and function of all cells depend on an adequate supply of oxygen. Reduced amount of oxygen in blood (hypoxemia) leads to tissue hypoxia and anaerobic metabolism where lactate is the end product of anaerobic glycolysis. If not reversed, tissue hypoxia can rapidly progress to muscle fatigue, multiorgan failure, and death. Measurement of blood lactate concentration is used to monitor tissue oxygenation. Escape activities may result in tissue hypoxia and utilize anaerobic metabolism that result in production of lactate acid in the muscle and in the blood. Juvenile shortnose sturgeon exposed to five minutes of forced activity resulted in a six-fold increase (to >6µmol/g) in muscle lactate concentrations (Kieffer *et al.* 2001). Muscle lactate concentrations had returned to resting levels (<1µmol/g) after six hours of rest. In similar studies, plasma lactate levels in sturgeon were low at resting (<1.0 mmol/L for all species), increased after exercise (shortnose: 1.0; Baker *et al.* (2005), 1 to 5;Brown and Kieffer (2018), Atlantic: 1.7; Baker *et al.* (2005), white sturgeon: 1.1 to 2.5; McLean *et al.* (2016)), and returned to resting levels after two hours. In contrast to the cortisol response, the plasma lactate level in white sturgeon did not differ between fish tested at winter water temperatures compared to fish tested at summer water temperatures (McLean *et al.* 2016). Baker *et al.* (2005) found that plasma lactate accumulation in Atlantic sturgeon and shortnose sturgeon differed between the two species while at rest and this difference was manifested after the forced chasing.

Green sturgeon emersed for one minute in air at 11 degrees Celsius increased lactate levels from a few mmol/l before treatment to a peak above 6 mmol/l after 30 minutes following the treatment (Lankford *et al.* 2003). Plasma lactate levels were still elevated, though not statistically significant, after six hours. In contrast, thirty seconds of air emersion of *Scaphirhynchus* sturgeon did not result in increased plasma lactate levels (Barton *et al.* 2000).

Struthers *et al.* (2018) measured significant increases in the physiological stress indicators of shortnose sturgeon exposed to a catch and release fishery in the Saint John River, Canada. Lactase had a slow response and the highest values were measured at the end of the test duration of two hours. Beardsall *et al.* (2013) found that Atlantic sturgeon that were either caught by trawl or a weir in the inner Bay of Fundy, Nova Scotia, differed in that Atlantic sturgeon caught by trawl had significantly elevated lactate levels (avg. 3.2 mmol/L) compared to sturgeon caught in a weir (avg. 1.0 mmol/L). Further, there were a significant positive correlation between handling time and blood lactate concentrations in trawl-captured Atlantic Sturgeon, i.e. handling time was a significant predictor of blood lactate concentrations.

These and studies of other sturgeon species show that sturgeon caught in fishing gear compensate with increased anaerobic metabolic activity. However, the measured lactate levels in sturgeon are generally low compared with teleost fishes. Further, the studies show that the return to pre-stress conditions can be rapid once the sturgeon is no longer exposed to the stressor.

Tertiary Stress Responses

There is a metabolic cost associated with stress and one way to measure the metabolic rate is to measure the changes in oxygen consumption. Kieffer *et al.* (2001) found that the manual chasing of juvenile Atlantic sturgeon and shortnose sturgeon for five minutes resulted in a physiological stress response with an approximately twofold whole-body increase in oxygen consumption and ammonia excretion rates compared to resting state. However, the responses are small compared to what is observed in more active fish. Oxygen consumption rates decreased to control levels within 30-minutes after the treatment for both species but ammonia excretion remained high in Atlantic sturgeon four hours after treatment.

Other indicators of stress such as change in osmolality also show less response to forced activity than what is seen in most teleost fishes. For instance, five minutes of chasing Atlantic sturgeon and shortnose sturgeon did not change osmolality or ion concentration (Baker *et al.* 2005, Kieffer *et al.* 2001).

Physiological stress responses can result in an impaired reflex response indicating a reduced ability to sense and respond to environmental threats. Reflex response is scored based on a series of tests including ventilation, mouth extension, orientation, tail grab, and body flex. McLean *et al.* (2016) found that white sturgeon were "surprisingly sensitive to fisheries stressors" though the response occurred at higher level of stress than what have been observed in teleost fishes. Sturgeon placed in shallow water that just partially covered the body and let trashing lost some reflexes after five minutes while control fish retained all reflexes. After 15 minutes, the number of reflexes that were impaired were significantly increased with some individuals experiencing loss of all the reflexes tested. Body flex and tail grab responses were impaired at the longer treatments and was related to white muscle exhaustion signified by the increased presence of plasma lactate in these groups. Orientation and buoyance were also affected. The treatment likely resulted in the loss of control of the swim bladder, subsequent inflation of the swim bladder, and consequent anterior positive buoyance. Treatment duration increased the time for all reflexes to return to normal conditions. Similar reflex impairments were observed in shortnose sturgeon exposed to air, exhaustive exercise, and catch by anglers in a fishing derby (Struthers *et al.* 2018). Increasing the air exposure time (2, 5, and 10 min) resulted in the increasing impairment of reflexes. These results shows that capture and handling stressors exhaust energy supply and affect the vitality of sturgeon.

Broell *et al.* (2016) used pop-up satellite tags that recorded swimming behavior and movements of shortnose sturgeon for two days after the tagged fish were released to measure post handling stress. The tagged sturgeon showed from two to five hours of resting behavior after release which corresponds to the physiological recovery period observed in sturgeon exposed to handling and exhaustive exercise stress (Baker *et al.* 2005, Kieffer *et al.* 2001). The authors found it most likely that the sturgeon used the flattened body and large pelvic fins to hold against the substrate to save energy and compensate for post-handling stress. However, the shortnose sturgeon also engaged in short time-scale burst swimming acceleration events just post-release that may have been related to tagging stress or tag removal behaviors. Though the burst swimming accelerations were a small percentage of the total behavioral repertoire, the activity is substantially more energy demanding and, therefore, considerably affects the total energy budget. Overall, Broell *et al.* (2016) concluded that stress from the handling and tagging resulted in short-term (acute) effects on behavior and potential long-term (chronic) effects on survival.

Ultimately, catch and handling stress can result in reduced survival. Beardsall *et al.* (2013) had a minimum 94 percent survival over a five-month period (defined as the detected tag stopped moving) of Atlantic sturgeon captured by otter trawl, tagged with radio transmitters, and released. All of the Atlantic sturgeon caught in a weir, which expose the sturgeon to substantially less handling survived over the duration of the study.

A large variation in stress responses among individuals, populations, and species is common. In general, sturgeon stress responses to stressors are of less intensity and the response subsides quicker than what has been observed in most teleost fishes (Barton 2002, Barton *et al.* 2000, Kieffer *et al.* 2001, Struthers *et al.* 2018). While the intensity of physiological response is considered an indication of the stress level, it is not clear what the interspecific variation means in terms of adverse stress effects. The results above suggest that Atlantic sturgeon and shortnose sturgeon's responses to stressors is different than those typically seen in other fish and they may have a reduced ability to respond physiologically to exhaustive situations such as when captured in fishing gear. However, the above studies do show that Atlantic sturgeon and shortnose sturgeon respond to capture and handling by modifying endocrine and metabolic activities. The intensity of many primary and secondary physiological responses (especially plasma lactate) increased with the increasing duration of stressor exposure. The responses also increase when the sturgeon are exposed to more than one stressor (e.g., capture and transport). The observed increases in plasma lactate indicate an oxygen cost. Recovery from physical exhaustion requires that a surplus of oxygen must be delivered to tissue, which leads to a deficit in oxygen available for normal behavior, and thus inhibiting movements such as migration and feeding (Beardsall *et al.* 2013).

The few studies that have been conducted on sturgeon tertiary responses that link capture and handling exposure to the whole animal show modified behavioral vitality (e.g., reduced reflex responses). The proposed project will expose sturgeon to a duration and intensity of stressors that substantially exceed what they experience in experimental tests or would normally experience in the wild.

You propose several measures to minimize stress of the sturgeon caught in the trawl. The handling, holding, weighing, measuring, and photographing procedures will follow our protocols (Kahn and Mohead 2010). You will fish in the direction of the tide for a short duration (typically 10 minutes, with a maximum tow duration of 15 minutes) at the lowest speed required to keep the doors spread to minimize stress during trawling. To minimize capture and handling stress, researchers will hold sturgeon in net pens or in holding tanks (as available), provide fish with a continuous flow of water, and minimize the amount of time the fish are handled and kept. For most planned procedures, the total time required to complete routine handling and tagging would be no more than 15 minutes. Moreover, following processing, sturgeon would be returned to the net pen or holding tank for observation and recovery prior to release. Sturgeon would be checked for buoyancy problems and treated with a slimecoat restorant prior to release, as well as monitored for proper swimming behavior after release. Total holding time (from capture to release) would never be longer than three hours, including the transport time to the upstream release location.

Nevertheless, the sturgeon will be exposed to multiple stressors over a longer period and given the observed stress responses reported in the literature, we conclude that the sturgeon will be at some level of exhaustion and reduced state when released. Therefore, we expect the sturgeon to have an increased vulnerability to energy demanding conditions and reduced ability to respond to environmental cues at the time of release.

7.6.3.2 Relocation

As outlined above, we expect the relocated sturgeon to be in a state of heightened stress but that the fish will return quickly (within hours) to pre-stress conditions once the stressor is removed. However, you propose to relocate the Atlantic sturgeon and shortnose sturgeon to river reaches approximately 61 km upstream of their capture location (to approximately RKM 193). Under natural conditions, fish seek physical and biological habitat features that meets their biological needs. Features include water currents, substrate, water depth, temperatures, water quality, forage availability, presence of conspecifics, predator refugia, etc. Fish that are moved out of the habitat that provides for their biological needs would be expected to experience stress and respond with compensatory behavior to re-establish conditions that meet their needs. Because of the time of year, any sturgeon captured in the Marcus Hook area will be overwintering there. Weather permitting, all sturgeon removed from Marcus Hook will be relocated to an area where overwintering has been documented; if weather and/or river ice prevents researchers from transporting the sturgeon to an established overwintering site, they will release the sturgeon as far upstream as possible from Marcus Hook. Here, we consider the effects of removing sturgeon from one overwintering location and placing them in another overwintering location.

The available information indicates that sturgeon collected in the Marcus Hook area are likely to be juvenile (including young of year) or adult shortnose sturgeon or juvenile (including young of year) Atlantic sturgeon. Many adult shortnose sturgeon, including those that will spawn in the spring, overwinter in dense aggregations near Duck and Newbold Island (RKM 190-210). Tracking of individuals in these areas indicate that they make only localized movements and remain within a 0.5-10 km area (O'Herron *et al.* 1993). Juvenile and smaller population of adult shortnose sturgeon overwinter in lower reaches of the river and may be present in the Marcus Hook area (Brundage and O'Herron 2014b, Brundage and O'Herron 2009, ERC 2016, 2017, 2018). During the winter months, subadult and adult Atlantic sturgeon are located outside of the Delaware River (Fisher 2011). Juvenile Atlantic sturgeon are present in the Marcus Hook area in the winter (Brundage and O'Herron 2014b, ERC 2016, 2017, 2018, Fisher 2011).

Relocation will necessarily remove the sturgeon from the habitat conditions that meets their needs and into a different environment. While you state that sturgeon are known to use the reach where they will be released, we do not expect that the exact release site (including the fact that these benthic species will be released in the upper water column) will meet the conditions preferred by the sturgeon. Thus, it is likely that the release will be an additional stressor.

In temperate and northern waters, winter conditions restrict the preferred habitat of fish species (Cunjak 1996, Hurst 2007, Weber *et al.* 2013). During low water temperatures in the winter, sturgeon typically reduce their home range, become sedentary, and seek deep areas where water current velocities are relatively low (Kynard *et al.* 2016, Thayer *et al.* 2017). Relocation will disrupt such behaviors and it is unlikely that they will be released in an area that immediately provides the preferred stream conditions. It is possible that winter aggregation such as is observed with shortnose sturgeon is not only a consequence of crowding in limited availability of preferred habitat but is also a consequence of social behavior (Kynard *et al.* 2016). Thus, we conclude that the released sturgeon may not be able to immediately find conditions where they can return to a pre-stress state and homeostasis but rather remain in a state of stress until they settle in habitat with suitable conditions.

We would expect the sturgeon to compensate for the stress by re-establishing in suitable microhabitats within the release reach and return to pre-stress levels if such habitat is present. On the other hand, being released in unfavorable conditions can maintain the elevated alertness and stress responses post-release. Sturgeon may also respond to unfavorable conditions by moving out of the reach and migrating to other parts of the river. During the three previous blasting seasons, a majority of the relocated sturgeon of both species moved quickly (within days or weeks) downstream after their release (ERC 2017, 2018). Several moved more than 100 km downstream to below RKM 100. Both the Atlantic sturgeon and shortnose sturgeon are able to detect and respond behaviorally to water conditions that affect growth and metabolism (Niklitschek 2001, Niklitschek and Secor 2010). Therefore, the downstream migration may indicate unfavorable conditions at the relocation site. Alternatively, the sturgeon may simply have responded to being released in a different river reach by moving downstream or their movements may be a combination of both.

Low water temperatures can be detrimental to fish, and fish die-offs during cold snaps have been observed (Hurst 2007). A larger number of the shortnose sturgeon were captured during the 2017/2018 season relocation trawling that in previous year. It was suggested that slightly colder upstream waters might have caused the sturgeon to migrate downstream (ERC 2018). Thus, unfavorable water temperatures may occur during periods of very low temperatures. Further, substantial icing occurred on the river in early January. Icing may hinder the sturgeon's ability to breach the surface to gulp air to fill their swim bladder necessary to maintain preferred buoyance. Physostomous fishes, such as sturgeon, have an open swim bladder connected to the digestive duct (esophagus). Sturgeon are unable to secrete air into their gas bladder via physiological mechanisms, and the air in the gas bladder is lost over time through diffusions. Thus, they need to make occasional visits to the surface to gulp air to inflate their swim bladder to maintain the desired buoyance in the water column (Logan-Chesney *et al.* 2018, Sulak 2012, Watanabe *et al.* 2008). If icing is severe as it seemed to have been the case during the 2017/2018 winter, then the sturgeon relocated to the upstream areas before the icing occurred could have been hindered from gulping air to inflate their swim bladder. This may also have caused the downstream movements.

It is generally concluded that the smaller home range and habitat preference (deep, slow water to minimize the energetic cost of swimming and holding) in sturgeon and fish in general during the winter is related to conservation of energetic resources to survive changing river conditions and reduced feeding (Kynard *et al.* 2016, Kynard *et al.* 2000, Thayer *et al.* 2017). Studies tracking the movements of juvenile sturgeon in the Delaware River indicate that individual behavior is diverse, with some individuals establishing a relatively small "home range" (see Fisher 2011) during the winter months and others exhibiting extensive movements. From the mid-November to early March period, young of the year Atlantic sturgeon either stayed within a small home range (less than 1 km) near the Marcus Hook anchorage (RKM 130) or made extensive movements (distances up to 50 km) between Philadelphia (RKM 154) and Roebling (RKM 199). However, the river of the Marcus Hook range is more tidally influenced, wider (>1000 m), and the navigation channel is a smaller portion of the channel than the narrower and less tidally influenced channel at the relocation reach (~250 m wide). High flow events increases the demand on the swimming performance of fish and thereby the use of energy reserves if they are not able to relocate to river sections or features that protect them from high water current velocities. Peak flow at Trenton usually occurs in early April but varies from year to year. For instance, in 2018, increased flows occurred in January and in late February/early March (https://www.state.nj.us/drbc/library/documents/Mont-Trent.pdf) when the sturgeon were relocated to upstream reaches. We expect that the characteristics (i.e. tidal influence and wider channel) of the Marcus Hook range provide a more diverse flow regime, and thereby provide a larger range of suitable water currents than the upstream release location above Burlington, New Jersey. Therefore, the upstream release site may not provide winter refugia to the same extent as the capture location.

Sturgeon holding against high water flows and/or engaging in winter migrating will necessarily increase their energy consumption and have a higher energy demand. As, mentioned above, the habitat shift in fall by sturgeon to deeper river features with relative low flow is likely related to the energetics of over wintering. Experiments on shovelnose sturgeon showed that extended periods of low water temperatures (<12°C) can deplete energy reserves and lead to higher mortality (Kappenman *et al.* 2009). Deslauriers and Kieffer (2012) found that shortnose sturgeon had low critical swimming performance and endurance at water temperatures of five degrees Celsius. Critical swimming speed of juvenile Atlantic sturgeon is also generally lower than other sturgeon species of the same size (reviewed by Wilkens *et al.* 2015). Several authors have noted that sturgeon respond to high water velocity by using their broad pectoral fins and relative flat body shape to hold positon at the bottom rather than swimming against the current. Further, we expect Atlantic sturgeon and shortnose sturgeon to reduce feeding or not feed at all during winter (Kynard *et al.* 2016). Therefore, relocating sturgeon into areas with higher water currents or that illicit long distance movements (about 100 km for some during previous relocations) will reduce energy reserves of the relocated sturgeon.

Intermediate salinities may limit osmoregulatory costs and provides for greater winter survival by alleviating osmotic stress (Hurst 2007). Both species are found aggregating in the saltwater-freshwater interface during the winter, and Atlantic sturgeon salinity preferences (YOY: 3.5−18.5 ppt, juvenile: 18.5−25.5 ppt) can determine (and limit) the extent of their preferred winter habitat (Schlenger *et al.* 2013). The blasting site (RKM 125.5 to 135.2) is located just upstream of the normal salinity front (approx. RKM 112) during the winter months. In February 2015, the salinity front extended to RKM 129. In contrast, the relocation site is far upstream of the salinity front and is, during normal conditions, freshwater. The low but saline waters of the Marcus Hook range, therefore, may provide conditions of less osmoregulatory cost compared to the release site. This may be especially important for juvenile Atlantic sturgeon that use a gradual salinity gradient for physiological development as they move into increasing salinities with age. The review of charts provided by you showed that, once released, a majority of the radio tagged fish moved quickly downstream past the blasting area to RKM 100 or below before returning upstream to the Marcus Hook Range (south end at RKM 122.6). The reason for this downstream movement past the capture location with subsequent upstream movement is unknown but it may be related to changes in salinity. Oxygen consumption increase and growth decreases at both lower and higher salinities, the optimal concentration being higher for one-year-old or older Atlantic sturgeon (Schlenger *et al.* 2013). Being relocated from their home range, the sturgeon may have moved downstream until unfavorable salinity concentrations were present or the fish may have moved into iso-saline waters after exposure to freshwater to achieve physiological homeostasis and then moved back up to their original home range.

While the Atlantic sturgeon and shortnose sturgeon do not show responses to physical disturbances of a magnitude similar to those observed in most teleosts of a similar size, they do respond to stressors with a typical series of behavioral responses (e.g., increased ventilation, rolling over, tiring) and increased metabolism. The capture, handling, and transport is expected to induce stress responses and increase energetic demand. Thus, releasing the sturgeon in winter at a site potentially lacking flow refugia and the downstream migration during a period when sturgeon have reduced feeding is likely to deplete their energy resources.

7.6.3.3 Multi-season Captures

The proposed blasting and relocation is the fourth season. Since we expect capture, handling, and relocation to have some adverse effect on the sturgeon's condition, recapture over multiple seasons may result in additional stress.

Number and percentage of multi-season Atlantic sturgeon recaptures are provided in Table 18 and of shortnose sturgeon recaptures are provided in Table 19 The majority of Atlantic sturgeon captured in the relocation trawling have been young of the year with very few individuals considered two-year olds or older. In the Delaware River, Atlantic sturgeon between the ages of two and five may start movements into higher salinities (i.e. lower estuary and the Delaware Bay) and will eventually start their coastal migrations. Therefore, we expect that only Atlantic sturgeon captured as young of the year in one season will be recaptured the following season. Based on data from previous seasons, we expect that up to 4.5 percent of the one-year old Atlantic sturgeon that will be captured during relocation trawling in 2018-2019 will be recaptures from the previous (2017-2018) relocation trawling.

Table 18. Summary of Atlantic sturgeon recapture during relocation trawling. The light gray cells represent the number and percentage of sturgeon captured and recaptured during the same season. The unfilled cells show the number of sturgeon captured during one season (vertical) that were recaptures of a previous season (horizontal).

Year	Feasibility study 2014 recaptures	Relocation 2015/16 recaptures	Relocation 2016/17 recaptures	Relocation 2017/18 recaptures
Feasibility study 2014	1 (2.7%)			
Relocation Trawl 2015/16	0	16 (4.0%)		
Relocation Trawl 2016/17	0	18 (4.5%)	17 (4.4%)	
Relocation Trawl 2017/18	0	0	6 (1.5%)	95 (3.8%)

The majority of shortnose sturgeon captured during previous seasons were older juveniles or adults (ERC 2017, 2018; Figure 7). Thus, we expect the multi-season recaptures to be adult shortnose sturgeon. During the 2017-2018 season, about 2.7 percent of shortnose sturgeon from each of the three previous seasons were recaptured (Table 19). Assuming that the 2018-2019 relocation trawling will capture 2.7 percent of the shortnose sturgeon captured during the feasibility study and each of the three previous seasons, then a total of 28 adult shortnose sturgeon will be multi-season recaptures during the proposed 2018-2019 relocation trawling (Table 20).

Table 19. Summary of shortnose sturgeon recapture during relocation trawling. The light gray cells represent the number and percentage of sturgeon captured and recaptured during the same season. The unfilled cells show the number of sturgeon captured during one season (vertical) that were recaptures of a previous season (horizontal).

	Feasibility study 2014	Relocation 2015/16	Relocation 2016/17	Relocation 2017/18
Feasibility study 2014	0			
Relocation Trawl 2015/16	0	1 (0.9%)		
Relocation Trawl 2016/17	0	2 (1.8%)	6 (2.0%)	
Relocation Trawl 2017/18	2 (3.0%)	3 (2.7%)	8 (2.7%)	2 (0.4%)

Table 20. Expected shortnose sturgeon recaptures from each previous season based on 2.7 % of shortnose sturgeon captured during the season (see Table 19).

Season	2014 Feasibility	2015/16 relocation	2016/17 relocation	2017/18 relocation	Total
Recaptures	2	3	8	15	28

7.6.3.4 Effects

Condition and Growth

Exposure to stress results in energy being diverted such that, energy available for other necessary activities, for example, growth and cellular maintenance is reduced accordingly. Further, relocation and subsequent movement during winter when sturgeon foraging is reduced, increases their energy demand and depletion of stored energy. Therefore, we would expect that the sturgeon that were captured and recaptured in the same season would have lost weight and, consequently, would have a reduced conditions factor[20] (weight relative to length). We have not been provided with data on the condition factor for sturgeon that were recaptured during the same season. Therefore, it is difficult to estimate the extent of the effects that these activities will have on sturgeon fitness or the proportion of fish that may experience a reduction in energy resources. Because all (estimated 1,841) of the sturgeon that will be caught and relocated during the 2018-2019 (or 2019-2020) relocation trawling will be exposed to stressors, we expect all of them to experience some degree of reduced energy reserves, weight, and condition.

Starving Persian sturgeon for four weeks reduced the weight and growth rate of the sturgeon but the fish mostly regained their condition after four weeks of re-feeding at saturation (Yarmohammadi *et al.* 2015). Therefore, we expect that the captured sturgeon would compensate for any loss in energy reserves during winter by increased feeding during the warmer months. Harold Brundage with ERC provided us with information on September 5, 2018, on conditions factors for sturgeon captured during the first season (2015-16) and then recaptured again the second season (2016-17). The median condition factors (Figure 9) for the Atlantic sturgeon and shortnose sturgeon were within the normal range of sturgeon for both the first capture and for the recapture (Beamish *et al.* 1996, Craig *et al.* 2005). However, of all the sturgeon (39), multi-season recaptures, 27 (61.5%) had a decreased condition factor at second capture compared to the first capture. Of these, half of the 24 Atlantic sturgeon recaptures had a reduced condition factor while the other half had an increased conditions factor. Out of the 15 recaptured shortnose sturgeon, the condition factor for three (2%) had increased and the condition factor for 12 (98%) had decreased. In general, the changes in condition factor (positive or negative) were small (Figure 10).

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[20] The condition factor was calculated as K = 100000 (W/L^3), where W = weight in grams and L = fork length in mm.

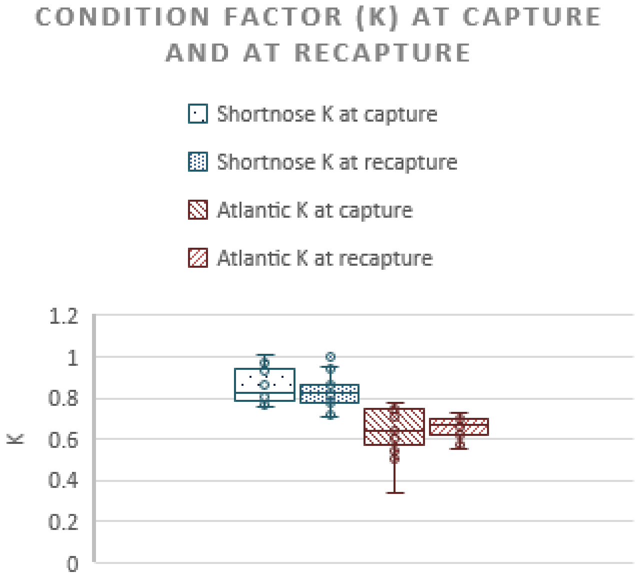

Figure 10. Box plot of the condition factor (K) of Atlantic sturgeon and shortnose sturgeon at capture in the 2015/16 relocation trawling and at recaptured in the 2016/17 relocation trawling. The middle line of the box represents the median, the bottom line of the represents the 1st quartile and the upper line the 3rd quartile, and the whiskers represents the interquartile range. Points are outliers.

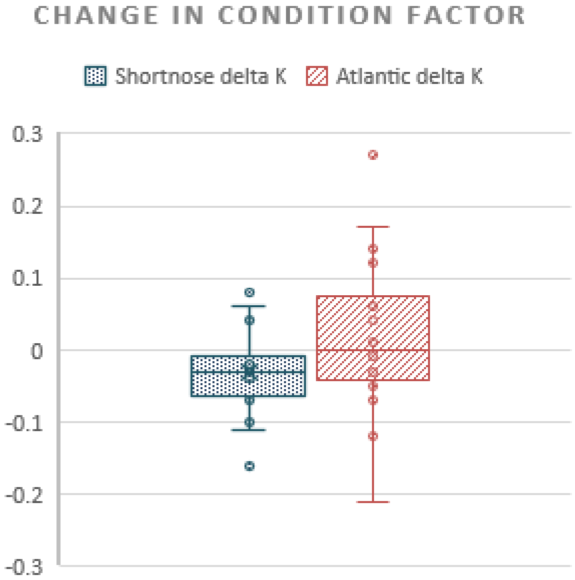

Figure 11. Box plot of the change in condition factor (K) of Atlantic sturgeon and shortnose sturgeon at capture in the 2015/16 relocation trawling and recaptured in the 2016/17 relocation trawling.

We recognize that the weight of a fish is influenced by many factors, such as reproductive condition, age, time of year, feeding status/rates, and, probably for fish collected by trawl, whether their stomach contents were regurgitated during capture. Thus, a change in the condition factor over time does not necessarily represent a change in the true condition of the fish. The 50/50 chance of a positive or negative change in condition factor by the Atlantic sturgeon could indicate a random outcome of the above factors. However, the majority of the shortnose sturgeon had a negative change in condition factor. Thus, despite of the uncertainty in observed condition factor, the observed decrease in condition from the first capture to the second capture of relocated sturgeon may indicate that capture and relocation comes with a cost that the sturgeon are not fully able to compensate for over the warmer months. We expect all the sturgeon that are relocated (1,841 of a combination of Atlantic and shortnose sturgeon) will experience a reduction in their condition compared to what they would have experienced if not captured. The sturgeon are expected to regain their condition over the summer but about half of the Atlantic sturgeon and the majority of shortnose sturgeon may not be able to fully compensate for the effects of capture and relocation.

7.6.3.4.1 Mortality

Sturgeon are generally considered tolerant to catch and release in fishery by-catch and to scientific capture and release. However, given the above considerations of stress, we find it likely that the capture, handling, and transport activities together with relocation will result in mortality of both Atlantic sturgeon and shortnose sturgeon. Beardsall *et al.* (2013) estimated a

94 percent survival of subadult and adult Atlantic sturgeon caught in one-hour otter trawls based on minimal detection of radio tagged fish. You provided information that two (0.8%) Atlantic sturgeon were "lost" out of 238 radio tagged fish over three seasons of relocation trawling. In the study by Beardsall *et al.* (2013), much larger sturgeon were caught, a longer trawl was used, and the study was conducted in a very different environment (i.e. a large open bay with marine waters). Thus, the four percent potential mortality may not be representative of the relocation trawling. Minimal detections do not necessarily mean that these fish had died. Minimal detections can also be caused by electronic failure of the tag or, more likely, expulsion of the tag through the surgical incision, vent, or abdominal wall. However, to be conservative and given the above discussion about stress and wintering, we assume that the loss of tag detections is representative of a post release mortality. Further, during the three seasons, 2.1, 4.35, and 3.79 percent of Atlantic sturgeon and 0.90, 2.00, and 0.37 percent of shortnose sturgeon within-season recaptures occurred (Table 18 and Table 19). An additional small percentage of multi-season recaptures also occur. Adverse effects from catch, handling, and relocation would be more likely for fish recaptured twice in one season or that were recaptures from the previous season's relocation trawling. Thus, we find it reasonable that 0.8 percent or 15 of the estimated 1,841 sturgeon that will be captured in the proposed relocation trawling will die because of capture and handling stress followed by the release at an upstream location during winter.

As we do not know the relative proportion of Atlantic and shortnose sturgeon in these reaches of the Delaware River, we cannot reliably predict the ratio of the shortnose and Atlantic mortalities. Based on the life stages that occur in the area, the shortnose sturgeon mortalities could be young-of–the–year, juvenile, or adults; the Atlantic sturgeon could be young-of-the-year or juveniles from the NYB DPS.

7.6.3.4.2 Long-term Growth

Most shortnose sturgeon captured were older juveniles or adults though some smaller, likely young-of-the-year were also captured. Reduced growth can delay age at maturity, result in adults postponing spawning, or reduce the fecundity of mature adults.

Atlantic sturgeon's movement into marine environments is size dependent and the age at which an individual enters the marine environment will be dependent on its growth rate. Thus, a reduction in the growth of a one-year-old Atlantic sturgeon can delay entry into marine waters and coastal migration. Coastal migration support growth of sturgeon to maturity. Thus, depending on the magnitude of reduced growth and the extent of delayed marine migration, multi-seasonal recaptures could affect fecundity at maturity and/or age at maturity.

Based on the above information, we expect that capture and relocation will affect the conditions of all captured and relocated sturgeon. A negative effect on the fish's condition may still be manifested in some sturgeon the following winter. Over the long term, relocated sturgeon evidenced seasonal movement patterns typical of those observed in previous studies of acoustically-tagged sturgeon in the Delaware River (Brundage and O'Herron 2014b, Brundage and O'Herron 2009, ERC 2006a, b), suggesting that trawling and relocation had no significant effect on the sturgeon seasonal movements (information in your June 4, 2018, draft biological assessment). Therefore, we expect that the majority of the relocated Atlantic sturgeon and shortnose sturgeon will replenish the loss of energy resources once they establish a new home range and foraging activity increases with increasing water temperature. Based on these considerations, we do not expect the one-time capture and relocation to affect the long-term growth of either of the species or the age at which the Atlantic sturgeon enter oceanic migrations.

As outlined above, half of the Atlantic sturgeon recaptures experience some reduction in their conditions the following season. Because of the effects related to capture and relocation, we expect that a second sequential season of capture, handling, and relocation of the Atlantic sturgeon that had a reduced condition will result in a second season of reduced condition. Thus, half of the multi-season recaptures (up to 4.5 % of the total captures of one-year olds) will experience some reduced growth, and the entry into marine waters and initiation of coastal migrations may be delayed for up to one year. However, male Atlantic sturgeon are expected to mature as 10+ years olds and females at age 15+ year olds (Hilton *et al.* 2016). Therefore, the delayed coastal migration is expected to have negligible effects on age at maturity and/or future fecundity as the sturgeon will have at least five to ten years of ocean migration and compensatory growth. The reduced growth in the river is not expected to affect the sturgeon's vulnerability to predation as even two year olds are too large for most predators.

Shortnose sturgeon reproduction

Reproduction is costly and iteroparous fish (i.e. having multiple reproductive cycles over the course of its lifetime) will have to replenish their energy reserves between reproductive events. In the worst case scenario, an adult female sturgeon captured and relocated will not be able to replenish the cost of previous reproduction and, therefore, it may postpone reproduction.

Brundage considered that about 19 of the 28 shortnose sturgeon captured during the 2015-2016 relocation trawling and outfitted with acoustic tags were adults (ERC 2018). You provided information in your June 4, 2018, draft biological assessment for this project that five of the adult shortnose sturgeon were detected on the spawning grounds in the lower non-tidal river (Yardley, PA; RKM 221) during the spring of 2016 and presumably spawned. Some of the other acoustically tagged adults may not have been detected even if they did move upstream. Further, the shortnose sturgeon spawn every three to five years. Therefore, it is reasonable to assume that five of the 19 represented the number of adults ready to spawn that year. Participation in spawning is evidence that one season of capture, handling, and relocation did not impose significant long-term stress on the adult shortnose sturgeon.

However, data provided by Harold Brundage shows that shortnose sturgeon recaptured during a second season had reduced condition factor. Given this, we find it reasonable that an adult shortnose sturgeon experiencing relocation trawling two seasons in a row will have reduced energy reserves. In a worst case scenario, all adult shortnose sturgeon recaptured for a second season may have been in their reproductive cycle. Thus, we expect that up to 14 (2.7% of the 539 shortnose sturgeon capture in 2017/18 rounded down) adult female sturgeon captured during the proposed trawling may postpone spawning to the following year (i.e. 2020) as a consequence of stress and energy depletion caused by the relocation over two consecutive seasons.

7.6.4 Acoustic Deterrence

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

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

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

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

7.6.4.1 Effects of Noise Produced by the Acoustic Deterrent

As noted above, the sound source will be set to produce a sound level of ≤204 dB re 1 μPa peak at a repetition rate of 20/minute for at least five hours prior to each detonation. Based on the results of the pilot study trials where the system operated at maximum energy (350 J), we expect peak noise to be 193 dB 1 μPa peak-to-peak (146 dB re 1 μPa single-pulse SEL) at a distance of 5.3 m from the sound source. The ensonified area will be approximately 0.4km^2, and all sturgeon behavioral responses are anticipated to occur within this ensonified area.

We expect potential injury to shortnose and Atlantic sturgeon upon exposure to impulsive noises greater than 206 dB re 1μPa peak or 187 dB re 1uPa cSEL. Peak noise levels will not exceed 193 dB re 1uPa^2·s peak and therefore will not exceed the peak noise exposure threshold of 206 dB re 1μPa.

In addition to the "peak" exposure criteria, which relates to the energy received from a single impulse, the potential for injury exists for multiple exposures to lesser noise. That is, even if an individual fish is far enough from the source to not be injured during a single impulse, the potential exists for the fish to be exposed to enough less noisy impulses to result in physiological impacts. The cSEL criterion is used to measure such cumulative impacts. The cSEL is not an instantaneous maximum noise level, but is a measure of the accumulated energy over a specific period of time (e.g., the period of time it takes to install a specific structure, such as a pile). For the proposed action, the impulsive noise will be generated for five hours prior to each detonation (max of two detonations per day). The cSEL is calculated by incorporating both the noise level associated with a single impulse as well as the total number of noise events. In this instance, this would mean accounting for every impulse over the entire day (i.e., one impulse every 2 seconds for two five-hour periods, for a total of 18,000 impulses). We calculated that the distance to the 187 dB re 1uPa cSEL isopleth is less than 5 meters from the noise source[21]. That means that in order to accumulate enough energy to be injured, a sturgeon would need to stay within 5 meters of the noise source for the entire 10-hour period that the system is operational. We do not expect this to happen because sturgeon in the Marcus Hook area are highly mobile. While some of the sturgeon tracked during the noise deterrent study did not avoid the ensonified area during the deterrent study, none of them were stationary for hours at a time. Therefore, it is not reasonable to anticipate that any sturgeon would stay within 5 meters of the sound deterrent system for 10 hours. Based on this, we do not expect any injury or mortality to result from exposure to the noise produced by the deterrent system.

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

Impulsive noise will be experienced in a 0.4km^2 area. Here, we consider effects to shortnose and Atlantic sturgeon that leave and/or are excluded from the ensonified area. Because of the time of year, any sturgeon in the Marcus Hook area will be overwintering there. The analysis and conclusions from the section above on the effects of relocation trawling on overwintering behavior apply here as well. Therefore, we do not anticipate any negative effects to shortnose or Atlantic sturgeon that are deterred from Marcus Hook.

As evidenced by the results of Brundage and O'Herron (2014a), displacement of pre-spawning adults will not affect the ability of these individuals to spawn successfully in the spring. No Atlantic sturgeon adults are expected to occur in the project area during the blasting window. All activities will cease by the time adults could be moving through the area in the spring, therefore,

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

we do not expect any disruption of Atlantic sturgeon spawning migrations or otherwise disruptions of pre-spawning activities or physiologies. Based on this assessment, all effects to shortnose and Atlantic sturgeon will be insignificant.

7.7 Pile Installation Effects on Sturgeon

The installation of piles via pile driving can produce underwater sound pressure waves that can affect aquatic species. The proposed construction of two range lights will involve the installation of a 48-inch diameter drilled steel caisson socketed into bedrock via a vibratory or impact hammer. A monopole will then be hammered into place within the steel caisson. USCG has agreed to not carry out in-water work from March 15 through July 31. During the time of year when in-water work will occur (August 1 – March 14), Atlantic sturgeon (eggs and yolk-sac larvae, post yolk-sac larvae, young of year, juveniles and subadults, and adults may be present) and shortnose sturgeon (young of year, juveniles, and adults) may be present. Because the entire project area is covered in a layer of silt, we would not expect eggs or yolk-sac larvae to be present where the piles will be installed. Here, we consider effects of drilling associated with installing the caisson as well as the installation of the monopole within the caisson.

The best available information (see FHWA 2012; 77 FR 23575; and NMFS 2011 Biological Opinion on the Columbia River Crossing), noise generated during drilling as well as oscillating and rotating steel casements for pile support will be well below the noise levels likely to result in physiological or behavioral effects (i.e., 206 dB re 1 µPa peak and 187 dB re 1 μPa^2-s cSEL for physiological effects and 150 dB re 1 µPa RMS for behavioral effects). Based on this, all effects to shortnose and Atlantic sturgeon exposed to noise associated with drilling into rock to facilitate the installation of the monopole will be insignificant and discountable.

It is unknown at this time whether the contractors will elect to use a vibratory or impact hammer, so we assume they will use an impact hammer, as they generally produce greater pressure levels than vibratory hammers and this creates a reasonable, but worst-case scenario of potential impacts to listed species. We determined the estimated noise at the source and distance to relevant thresholds for species in the action area using the NMFS Greater Atlantic Regional Fisheries Office (GARFO) Acoustic Tool spreadsheet (version updated 11/30/2016). We present the estimated sound levels and distances to species injury and behavioral thresholds associated with the proposed action in Tables 1-3.

Table 21: Proxy Projects for Estimating Underwater Noise

Project Location	Water Depth (m)	Pile Size (inches)	Pile Type	Hammer Type	Attenuation rate (dB/10m)
Geyserville - Russian River, CA	0	48"	CISS Steel Pipe	Impact	2

Table 22: Proxy-Based Estimates for Underwater Noise

Type of Pile	Hammer Type	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})
48" CISS Steel Pipe	Impact	198	185	175

Table 23: Estimated Distances to Sturgeon Injury and Behavior Thresholds

Type of Pile	Hammer Type	Distance (m) to $206dB_{Peak}$ (injury)	Distance (m) to sSEL of 150 dB (surrogate for 183 or 187 dBcSEL injury)	Distance (m) to Behavioral Disturbance Threshold (150 dB_{RMS})
48" CISS Steel Pipe	Impact	NA	135.0	185.0

As explained above, exposure to underwater noise levels of 206 dB_{Peak} and 183 or 187 dB_{cSEL} (depending on the life stage) can result in injury to sturgeon. In addition to the "peak" exposure criteria, which relates to the energy received from a single pile strike, the potential for injury exists for multiple exposures to noise over a period of time; this is accounted for by the cSEL threshold. The cSEL is not an instantaneous maximum noise level, but is a measure of the accumulated energy over a specific period (e.g., the period of time it takes to install a pile). When it is not possible to accurately calculate the distance to the 187 or 183 dB_{cSEL} isopleth, we calculate the distance to the 150 dB_{sSEL} isopleth. The further a fish is away from the pile being driven, the more strikes it must be exposed to accumulate enough energy to result in injury. At some distance from the pile, a fish is far enough away that, regardless of the number of strikes it is exposed to, the energy accumulated is low enough that there is no potential for injury.

For the piles being driven here, peak noise will be below the single-strike or peak threshold. Therefore, there is no potential for instantaneous injury. The only potential for injury would be if a sturgeon remained close enough to the pile for a long enough period of time to accumulate the energy associated with numerous strikes. For this project, the distance to the 150 dB_{sSEL} isopleth is no greater than 135.0 meters. As explained above, the area with noise loud enough to accumulate to injurious levels (the 183 or 187 dB re 1uPa cSEL isopleth in this case (depending on the life stage)) is smaller than the area encompassed by the 150 dB re 1uPa sSEL isopleth. In order to be exposed to potentially injurious levels of noise during installation of the piles, a sturgeon would need to be within 135.0 meters of the pile being driven and remain in that area for the duration of pile driving. This is extremely unlikely to occur as we expect that sturgeon will avoid areas with disturbing levels of noise (expected to occur upon exposure to noise of approximately 150 dB re 1uPa RMS). In this case, the distance to the 150 dB re 1uPa RMS extends 185 meters from the pile being installed. Therefore, we expect that sturgeon will not approach closer than 185 m from the piles being driven, and in the unlikely event that a sturgeon was closer than 185 m when pile driving began it would quickly move out of the noisy area. As such, we do not expect any sturgeon to be exposed to injurious levels of noise. While it is possible that Atlantic sturgeon eggs and yolk-sac larvae could be within 135.0 meters of the monopoles during the month of August, USCG has indicated that a soft layer of material (silt) covers the bedrock throughout the range light sites, and therefore the injurious effects of the 183 dB_{cSEL} being reached are extremely unlikely. Therefore, injurious effects of pile driving noise on sturgeon are discountable.

As explained above, sturgeon are expected to avoid the area where noise is louder than 150 dB re 1uPa RMS. This area is spatially (extends no further than 185m from the pile being driven) and temporally (no more than the few hours on a single day that pile driving will occur) limited. If any movements away from the ensonified area do occur, it is extremely unlikely that these movements will affect essential sturgeon behaviors (e.g., spawning, foraging, resting, and migration), as the Delaware River is sufficiently wide at the project location to allow sturgeon to avoid the ensonified area while continuing to forage and migrate and the area to be avoided is very small and will only be avoided for a very short period of time. Given the small distance a sturgeon would need to move to avoid the disturbance levels of noise, any effects will not be able to be meaningfully measured or detected. Therefore, the effects of noise on shortnose and Atlantic sturgeon are insignificant.

7.8 Vessel Traffic

7.8.1 Project Vessels Associated with Proposed Construction Activities

Deepening and maintenance dredging activities require the use of dredge and support vessels. Hopper and cutterhead dredges are autonomous vessels, while some mechanical dredging takes place from a barge with a mounted excavator. Barges typically require one or two tug boats to position them. Mechanical dredging also involves a scow vessel where contractors deposit the dredged material. A maximum of four project vessels (combination of barge, tug boats, and scows) would likely be needed for any of the deepening (aside from the blasting work) or maintenance dredging activities described in Table 1.

The blasting contractor, Great Lakes Dredge & Dock Company (GLDD) has performed dredging and rock removal operations with three major pieces of equipment: the dredge *New York*, dredge *No.54* and the drillboat *Apache*. Dredge *New York* is a 200 feet x 57 feet x 15 feet mechanical backhoe dredge with a total installed power of 3,434 hp (2,565 kW). Dredge *No. 54* is a 185 feet x 60 feet x 11 feet mechanical dredge with a total installed power of 2,340 hp (1,750 kW). A crew boat, the *Miami River*, services the dredge *No.54*. The *Miami River* is 40.0 feet x 6.0 feet. The drillboat *Apache* is 210 feet long, 60 feet wide, and has a linear drilling space on deck of 170 feet. The *Apache's* hull depth is 10.5 feet and the draft is 5 feet. The *Apache* is assisted by a 24-hour tug, *Bering Dawn*, as well as a crew boat, *Muskegon River*. The *Muskegon River* is 55.0 feet x 7 feet. Seven tugs are currently being used on the project (maximum draft of 16 feet), and GLDD has utilized five scows: *G.L. 501*, 5*02, 601, 602* and *65*. GLDD also utilizes the *Calcasieu River* for multi-beam hydrographic surveys in support of dredging operations. The

Calcasieu River is a 38.8 feet twin screw survey boat with a total installed power of 800 hp (597 kW).

GLDD has contracted two fishing vessels, the *Amy Marie* and the *Charisma,* for sturgeon trawling and relocation, respectively. The *Amy Marie* is an 85 feet x 24 feet fishing vessel with an installed 1,050 hp and a draft of 13.1 feet. The *Charisma* is a 45 feet x 10 feet transport vessel with an installed 825 hp and a draft of 5 feet. During blasting operations, two vessels are utilized to acoustically deter and monitor sturgeon with sonar. The *Integrity* is used for pre- and post-blast monitoring. The *Gannet* utilizes a sound deterrent system, which uses a 'boomer' to produce a low frequency sound.

Vessels for the light range project include one or two work barges for pile installation and dredging work, a tug boat to move the barges from site to site, and a skiff to transport the construction crew to the sites each work day.

7.8.2 Deepening and Maintenance of Federal Navigation Channels (Philadelphia to Trenton and Philadelphia to the Sea)

Throughout the consultation process on the Delaware River deepening project, you have maintained 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. The 45-foot channel depth will improve the economic efficiency of ships moving through the Delaware River ports, resulting in a reduction in total vessel trips. No induced tonnage (i.e., commodity shifts from other ports) will take place with the proposed project deepening. The largest vessels in the port fleet, crude oil tankers, currently lighter at Big Stone Anchorage in the naturally deep water of the lower Delaware Bay. These vessels will continue to carry the same tonnage from the origin ports but will be able to operate more efficiently in the Delaware River with a deepened channel from reduced lightering. Also, a deeper channel depth will allow a segment of the current container and dry bulk vessels to carry more cargo as well as allow a fleet shift to more efficient sized vessels. These factors will more efficiently apportion operating costs for the same amount of total tonnage and further reduce total vessel trips through the port (USACE 2011a).

Similarly, beyond the use of project vessels discussed in section 7.7.1, we do not expect maintenance of the 45-foot channel from Philadelphia to the Sea, nor maintenance of the 40-foot channel from Philadelphia to Trenton, to increase baseline levels of vessel traffic in the Delaware River. The effects of baseline (i.e., non-project related vessels) vessel traffic is included in the discussion of threats facing the species as addressed in the Status of the Species and Environmental Baseline sections of this Opinion.

7.8.3 Effects of Vessel Traffic on Sea Turtles and Sturgeon

7.8.3.1 Background Information on the Risk of Vessels to Sea Turtles

Project vessels performing maintenance dredging and beach nourishment in Reaches E and D transit areas where sea turtles are present. As mentioned, sea turtles are found in the Delaware Bay 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 percent of living and dead stranded sea turtles had propeller or other vessel strike injuries (Lutcavage *et al.* 1997). According to 2001 STSSN stranding data, at least 33 sea turtles (loggerhead, green, Kemp's ridley and leatherbacks) that stranded on beaches within the northeast (Maine through North Carolina) were struck by a vessel. This number underestimates the actual number of vessel strikes that occur since not every vessel struck turtle will strand, every stranded turtle will not be found, and many stranded turtles are too decomposed to determine whether the turtle was struck by a vessel. It should be noted, however, that it is not known whether all vessel strikes were the cause of death or whether they occurred post-mortem (NMFS SEFSC 2001).

Information is lacking on the type or speed of vessels involved in turtle vessel strikes. However, there does appear to be a correlation between the number of vessel struck turtles and the level of recreational boat traffic (NRC 1990). Although little is known about a sea turtle's reaction to vessel traffic, it is generally assumed that turtles are more likely to avoid injury from slower-moving vessels since the turtle has more time to maneuver and avoid the vessel. The speed of project vessels is not expected to exceed 10 knots. In addition, the risk of vessel strike will be influenced by the amount of time the animal remains near the surface of the water. For the proposed action, the greatest risk of vessel collision will occur during transit between shore and the areas to be dredged.

7.8.3.2 Background Information on the Risk of Vessels to Atlantic and Shortnose Sturgeon

The factors relevant to determining the risk to Atlantic and shortnose sturgeon from vessel strikes are currently unknown, but based on what is known for other species we expect they are related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of sturgeon in the area (e.g., foraging, migrating, etc.). Geographic conditions (e.g. narrow channels, restrictions, etc.) may also be relevant risk factors. Large vessels have been typically implicated because of their deep draft relative to smaller vessels, which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Larger vessels also draw more water through their propellers given their large size and therefore may be more likely to entrain sturgeon in the vicinity. Killgore *et al.* (2011) estimated that the large towboats on the Mississippi River, which have a propeller diameter of 2.5 meters, a draft of up to nine feet, and travel at approximately the same speed as tugboats (less than ten knots), kill a large number of fish by drawing them into the propellers. They indicated that shovelnose sturgeon (*Scaphirhynchus platorynchus*), a small sturgeon (~50-85 cm in length) with a similar life history to shortnose sturgeon, were being killed at a rate of 0.02 individuals per kilometer traveled by the towboats.

As the Mississippi and Delaware River systems differ significantly, and as we do not have the data necessary to compare shovelnose sturgeon densities in the Mississippi to shortnose or Atlantic sturgeon populations in the Delaware, this estimate cannot directly be used for this analysis. We also cannot modify the rate for this analysis because we do not know (a) the difference in traffic on the Mississippi and Delaware rivers; (b) the difference in density of shovelnose sturgeon and shortnose and/or Atlantic sturgeon; and, (c) if there are risk factors that increase or decrease the likelihood of strike in the Delaware. However, this information does suggest that large vessel traffic can be a major source of sturgeon mortality. In larger water bodies it is less likely that fish would be killed since they would have to be close to the propeller to be drawn in. In a relatively shallow or narrow area a big vessel with a deep draft and a large propeller would leave little space for a nearby fish to maneuver.

Although smaller vessels have a shallower draft and entrain less water, they often operate at higher speeds, which is expected to limit a sturgeon's opportunity to avoid being struck. There is evidence to suggest that small fast vessels with shallow draft are a source of vessel strike mortality on Atlantic and shortnose sturgeon. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MEDMR) staff observed a small (<20 foot) boat transiting a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. In another case, a 35-foot recreational vessel travelling at 33 knots on the Hudson River was reported to have struck and killed a 5.5-foot long Atlantic sturgeon (NYSDEC sturgeon mortality database (9-15-14)). Given these incidents, we conclude that interactions with vessels are not limited to large, deep draft vessels.

7.8.3.3 Effects of Project Vessel Traffic on Sea Turtles and Sturgeon

We estimate that as many as four project vessels may be used for each maintenance dredging or beach nourishment project described in Table 1 (see table for frequency of projects). In the information that you provided on September 18, 2018, you estimated that the hopper dredge will make from 140 to 210 vessel trips (two to three loads per day) to Buoy 10 during a 70-day period of dredging of Reach E each year. USCG has also described four project vessels for the light range project. The remaining season of relocation trawling, blasting work, and clean-up involves a combination of 21 project vessels. We do not expect all of these vessels to be operating at once, as many of them perform the same purpose and we understand them to be part of a rotation depending on availability, costs, and river conditions.

As noted above in the Environmental Baseline section (5.3.2), in 2015, there were 25,766 upbound and 25,808 downbound vessel movements within the Federal navigation channel between Philadelphia, PA and the Delaware Bay. The total number of vessel trips (upbound + downbound) was 51,574. Of those more than 50,000 trips, approximately 3,000 were deep draft vessels (tanker ships that are greater than 125,000 deadweight tons). From Philadelphia to Trenton, you maintain the 40-foot channel for commercial traffic, and have confirmed that deep draft vessels (e.g., bulk salt/gypsum, fertilizer, and scrap metal vessels) use the extent of that channel up to the Fairless Terminal on a regular basis. The USACE Navigation Data Center reports that for calendar year 2012 – calendar year 2016, the number of commercial vessel trips (inclusive of both upriver and downriver trips) in this portion of the river (from Alleghany Avenue in Philadelphia to Trenton) ranged from a high of 4,100 trips in 2015 to a low of 5,384 in 2014. This includes domestic and international vessels inclusive of self-propelled dry cargo, self-propelled tanker, self-propelled towboat, non-self-propelled dry cargo and non-self-propelled liquid tanker barge. Vessel drafts ranged from 1-43 feet with the vast majority in the 2-12 foot range.

Data combined from Delaware's Department of Natural Resources and Environmental Control (DNREC) and reports received by us through our sturgeon "salvage permit", indicates that of recovered sturgeon carcasses collected between 2005 and 2016, 92 sturgeon mortalities were attributable to vessel strikes (an additional 47 had an unknown cause of death).

We have assumed that the increase in vessel traffic from project vessels would increase the risk of vessel strike to shortnose or Atlantic sturgeon and that this would result in a corresponding increase in the number of sturgeon struck and killed in the Delaware River. However, as noted above, there are thousands of vessels operating in the action area each year. Given the high amount of vessel traffic in the waterbody, the increase in vessel traffic in the river due to project vessels is extremely small. Accordingly, the corresponding increase in the risk of strike is very small and cannot be meaningfully measured, detected, or evaluated and therefore, effects are insignificant.

Furthermore, the 45-foot channel depth improvement does not necessitate any expansion of the port facilities utilized for tonnage with the current 40-foot channel scenario; therefore, we do not expect any increase in vessel traffic due to the deepening or future maintenance dredging of the navigation channels; therefore, we do not expect deepening and maintenance to result in any increase in risk of vessel strike beyond what is considered in the environmental baseline and status of the species.

Stetzar (2002) reports that 33 of 109 sea turtles stranded along the Delaware Estuary from 1994-1999 had evidence of boat interactions (hull or propeller strike); however, it is unknown how many of these strikes occurred after the sea turtle died. If we assume that all were struck prior to death, this suggests 5 to 6 strikes per year in the Delaware Estuary.

We have considered the risk of vessel strike to sea turtles due to the addition of project vessels in the action area. Given the high amount of vessel traffic in the waterbody, the increase in risk of a strike due to the addition of the project vessels in extremely small. Additionally, these vessels will be traveling at slow speeds which reduces the risk of vessel strike with sea turtles. Based on this analysis, any increase in risk of vessel strike would be so small it would not be able to be meaningfully measured or detected and is, therefore, insignificant.

7.9 Habitat Impacts from Dredging and Construction Activities

Dredging involves removing the bottom material down to a specified depth; the benthic environment will be impacted by dredging operations. During cutterhead dredging activities, sand will be transported to disposal facilities or beaches. The pipe will be approximately 30” in diameter and be laid on the river bottom. The presence of the pipe will cause a small amount of benthic habitat to be temporarily unavailable to sturgeon and sea turtles. Material dredged with hopper dredge from Reach E will be transported and disposed of at Buoy 10. Buoy 10 is an approximately 92-acre, 25 to 40 feet deep, open water dredged disposal site in the Delaware Bay. Of the 92 acres, about 23 acres are too shallow (<25 feet) to be used. Only coarse material is disposed of at the site and the bottom consists of sand. Lastly, the construction of the light ranges in Reach B will permanently remove 20 square feet of soft substrate (only impacting sturgeon).

7.9.1 Effects on Sea Turtle Foraging

No sea grass beds occur in the areas to be dredged or at the Buoy 10 site; therefore, dredging activities and open water disposal are not likely to disrupt normal feeding behaviors for adult green sea turtles. Leatherback sea turtles forage primarily on jellyfish. Since jellyfish are in the water column and relatively mobile, they will not be affected from project activities. Records from previous dredge events occurring in the lower channel indicate that some benthic resources, including whelks, horseshoe crabs, blue crabs and rock crabs occur in the channel and are entrained during dredging (USACE 2009b, 1997).

Of the listed species found in the action area, loggerhead, Kemp’s ridley, and juvenile green 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 (Bjorndal 1997, Morreale and Standora 1998). As noted above, suitable sea turtle items occur in the channel. However, as also explained above, at least some areas of soft substrate in the channel experience daily disturbance (sedimentation from propellers/prop wash); we expect that this has some impact on the ability of these areas to support an abundant and diverse community of benthic invertebrates. This may mean that areas outside the channel are more likely to be used by foraging sea turtles; however, we do not have fine scale information on sea turtle forage items or sea turtle distribution that we could use to make a conclusive determination about foraging in the channel versus outside the channel. This disturbance is more likely to disturb or displace non-mobile organisms that occur at the surface of the sediment and is less likely to impact mobile prey (such as crabs) or benthic invertebrates that bury deep into the substrate (such as worms).

Dredging and open water disposal can effect sea turtles by reducing prey species through the alteration of the existing biotic assemblages; this occurs through the entrainment of prey items as well as displacement or crushing under the cutterhead pipeline that lies on the bottom and transports dredged material to the disposal site. 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 mobile sea turtle prey items as well as benthic invertebrates that do not have sufficient (or any) mobility to avoid the dredge. Similarly, disposal of dredged material at Buoy 10 is likely to cover some mobile sea turtle prey items as well as benthic invertebrates that do not have sufficient (or any) mobility to avoid the sediment plume and settlement. Wilber and Clarke (2007) reviewed studies on recovery of invertebrate fauna from open water disposal and dredging and found that recolonization in the majority of studies occurred within a year in temperate and cold climatic areas.

The area encompassed by the navigation channel within the Delaware River and Bay where sea turtles may be present as well as Buoy 10 takes up approximately 1.1 percent of the action area. Deepening in Reach E (~750 acres) of the Delaware Bay was completed on August 31, 2018. Therefore, recovery of the benthic community from the deepening dredging will occur before sea turtles return to the area in spring/summer 2019. However, you will dredge shoaled areas within the channel in any given year (you have indicated that dredging of up to 400,000 CY of sands and silts will occur annually in Reach E, while dredging of 1,000,000 CY of sands and silts in Reach D will occur on a three-year cycle). Shoals that are maintenance dredged in Reaches D and E will remove potential sea turtle foraging habitat, and while we do not have an estimate for the area of those shoals, we know that it will be a small percentage of the 1.1 percent of sea turtle foraging habitat in the navigation channel (i.e., you do not expect to be maintenance dredging the entire navigation channel in Reaches D and E, only shoaling areas). The disposal of dredged sand will impact up to approximately 79 acers at the Buoy 10 site annually. This is equal to approximately 0.02 percent of the total foraging area in the action area available to sea turtles.

While there is likely to be some reduction in the amount of prey, these losses are limited in space and time. That is, these reductions will only be experienced in the areas being dredged and will only last as long as it takes benthic resources to return to the area. Given the small portion of the total habitat available for foraging sea turtles, and the temporary nature of these impacts, any effects on foraging from periodic maintenance dredging of shoaled areas, disposal of material at Buoy 10, and temporarily removing habitat under cutterhead pipelines are too small to be meaningfully measured or detected, and are therefore insignificant. We do not expect that these reductions in forage will have impacts on the fitness of any sea turtles.

Concern has been raised that the deposition of material on beaches for beach nourishment 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 Oakwood Beach and the DMU sites between September and March; given the time of year, it is unlikely that these activities will affect spawning horseshoe crabs. Further, periodic beach nourishment for the DMU sites will be restricted to every six years (7 occurrences for the duration of this Opinion). Restoration of this beach 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, juvenile green, and Kemp’s ridley sea turtles. No effects to the prey base of adult green or leatherback sea turtles are anticipated.

7.9.2 Effects on Sturgeon Foraging

Shortnose and Atlantic sturgeon feed on a variety of benthic invertebrates. One of the major potential food sources for shortnose sturgeon is the Asiatic river clam (*Corbicula manilensis*) as this shellfish is very abundant (Brundage, pers. communication, 2014). While shortnose sturgeon feed on shellfish and other benthic invertebrates, shellfish typically make up a very small percentage of the prey base of Atlantic sturgeon; Atlantic sturgeon prey primarily on soft bodied invertebrates such as worms (Guilbard *et al.* 2007, Savoy 2007). The proposed dredging will occur in the navigation channel. As explained above in discussing effects to sea turtle foraging, we expect the daily disturbance in the navigation channel (e.g., sedimentation from propellers/prop wash) to have some impact on the ability of these areas to support an abundant and diverse community of benthic invertebrates; however, we expect that this disturbance is more likely to disturb or displace non-mobile organisms that occur at the surface of the sediment and is less likely to impact mobile invertebrates (such as crabs) or benthic invertebrates that bury deep into the substrate (such as worms). Dredging is likely to entrain and kill at least some of these potential sturgeon forage items. Turbidity and suspended sediments from dredging activities, as well as the placement of sand at the beneficial use sites and at Buoy 10 may affect benthic resources in those areas. As noted in Section 7.4.6, the TSS levels expected for all of the proposed activities (ranging from 5 mg/L to 475 mg/L) are mostly below those shown to have adverse effects on benthic communities (390 mg/L (EPA 1986).

Benthic sampling done by O'Herron and Hastings (1985) in association with past USACE maintenance dredging in the Delaware River found that *Corbicula* recolonized the dredge areas during the subsequent growing season. However, the post-dredge individuals collected were smaller than pre-dredge individuals and provided less biomass. O'Herron and Hastings (1985) found that adult shortnose sturgeon may not be able to efficiently utilize new molluscan colonizers due to the limited biomass until the end of the second growing season after dredging. Based on this information, sturgeon should only be exposed to a reduction in forage in the areas where dredging occurs every one to two years (i.e., the areas where the most frequent shoaling and maintenance dredging occurs, as described in Table 2). As noted above, the Buoy 10 disposal site consists of coarse sandy material. Though we do not know the faunal composition of the site, we would expect aquatic worms and other benthic fauna that provide forage for Atlantic sturgeon to occur in the substrate. We also expect free moving invertebrates to be present. Effects on benthic invertebrates from dredge material disposal depends on the quantity disposed and consequently the depth of the overburden (i.e. the thickness of the dredged material layer) as well as the frequency of deposition (Wilber and Clarke 2007). You have not provided information on the expected overburden from disposal of dredged material from maintenance dredging and it is difficult to evaluate the effect of dredge disposal at Buoy 10 on benthic invertebrates. Burrowing Polychaeta worms, amphipods, and mollusks can migrate vertically through sediment 15 to 32 cm deep (Maurer *et al.* 1982, Robinson *et al.* 2005). Benthic fauna that survived the dredging and dumping process can also contribute to quick recovery of the depositional sediment. Recovery of dredged disposal sites usually occur within a year in temperate waters (Wilber and Clarke 2007). However, the annual use of the site for open water sediment disposal may cause a chronic reduction in the quantity of fauna and the quality of the site for sturgeon foraging (Hatin *et al.* 2007a).

Both species of sturgeon may forage in the full extent of the action area, primarily over soft substrates. Using the data you have provided, the combined shoaling areas that are subject to frequent maintenance dredging and the approximately 100 acres of non-bedrock area that remains to be dredged in Reach B are approximately 1,276 acres. This area is approximately 0.27 percent of the total action area, 0.31 percent of the area in Delaware Bay, and 0.32 percent of the estimated soft substrate below the salt front (RKM 107.8).[22] Only the shoaling areas, or roughly 1,113 acres are likely to be dredged on an annual basis. In addition, approximately 79 acres (0.02% of habitat in the Bay) will be impacted by open water dredge material disposal at Buoy 10. Together, this represents about 0.33 percent of the area in the Delaware Bay.

Impacts from the placement of the cutterhead dredge pipe during beach nourishment will be minor and temporary. In sum, there is likely to be some permanent reduction in the amount of sturgeon prey in frequently dredged shoaling areas, as well as a temporary removal of habitat under the cutterhead pipeline, and the removal of 20 square feet under the new range lights. The Buoy 10 open disposal site will continue to support habitat for benthic invertebrates though some reduction in the quantity and composition of organisms is expected since the site will be used on an annual basis. However, the site is an extremely small portion of soft substrate within the Delaware Bay that provides habitat for invertebrates and forage for Atlantic sturgeon. Given the limited area where benthic resources will be removed or displaced, effects on sturgeon from reductions in benthic resources in a limited area and for limited periods of time, will be too small to be meaningfully measured or detected, and are therefore insignificant.

7.9.2.1 *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. However, Atlantic sturgeon feed over soft substrate with benthic worms being a major portion of their prey. 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 to no foraging during the winter (Kynard *et al.* 2016, NMFS 1996). The likelihood that shortnose sturgeon are actively foraging in the area where blasting will occur is low, but shortnose sturgeon could still be feeding in the vicinity of the blasting. As noted above, Asiatic river clams are a significant portion of the prey base of shortnose sturgeon in the Delaware River. Fine clean sand, clay, and coarse sand are preferred substrates for this clam, although this species may be present in lower numbers on almost any substrate (Belanger *et al.* 1985). 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

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[22] We used DNREC’s 2010 shapefile data “Delaware Bay Upper Shelf Bottom Sediments 2008-2010” to come up with a ratio of soft bottom substrate to hard bottom substrate in the areas they surveyed. We then made the assumption that the data they collected was a representative sample of the substrate in the action area, and extrapolated their findings to the rest of the Delaware Bay and the area below the salt front, as their benthic surveys did not extend past RKM 132.

area would be destroyed. The impact should not extend beyond the immediate blasting area as previous studies indicate that invertebrates are relatively insensitive to pressure related damage from underwater detonations (USACE 2000). This could be attributable to the fact that all the invertebrate species tested lack gas-containing organs, which have been implicated in internal damage and mortality in vertebrates (Keevin and Hempen 1997). Nevertheless, the area immediately surrounding the blast zone would be void of preferred sturgeon prey and thus, sturgeon would not be likely to forage in this area.

It is important to note, however, that while blasting will destroy all of the prey resources in the immediate area, the impacts will not be permanent and as discussed above for dredging, the benthic community will likely reestablish within two years. The area where remaining blasting will occur (20 acres) is very small relative to forage grounds in the action area (see discussion above regarding dredging effects to sturgeon foraging). Based on this information, blasting effects on sturgeon foraging will be too small to be meaningfully measured or detected, and are therefore, insignificant.

7.9.3 Effects of Deepening and Maintenance Dredging on Substrate/Habitat Type

During the consultation process, we requested information on the potential of the proposed deepening to alter the substrate type in areas to be dredged. If substrate type was altered, the benthic community that recolonizes the dredged area could be fundamentally different than the original community and this could affect the availability of forage items for listed species. However, you have indicated that the remaining sub-surface strata below the dredging pay-prism is consistent with the maintenance material removed during a typical dredging operation (USACE 2012, 2017b). 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). You have 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. You have 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.

Based on the information provided by you 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 Sections 7.4, 7.9.1, and 7.9.2. and 7.10.2. Effects to Atlantic sturgeon spawning habitat are considered in sections 7.4.6 and 7.10.1.

7.9.3.1 Effects to Shortnose Sturgeon Spawning and Overwintering Habitat

As described in Section 5.3.4, in the Delaware River, shortnose sturgeon movement to the spawning grounds occurs in early spring, typically in late March, with spawning occurring through early May, and sturgeon typically leaving the spawning grounds by the end of May. We expect spawning to potentially occur from RKM 214-238 from March 15 to May 31. A majority of adult shortnose sturgeon overwinter near Duck and Newbold Island but some adult and juvenile shortnose sturgeon overwinter downstream, including the Marcus Hook area. We generally expect overwintering to occur between November and the end of March.

Maintenance dredging of Reach C-D (RKM 212.5-214.5) is the only activity that may impact shortnose sturgeon spawning habitat. This Reach is only dredged for recreational use (to 12 feet), and is not regularly maintained (has not been dredged in past 30 years). If dredging were to occur in this Reach, it would only remove shoaled areas of the channel from Oct. 1 – March 15. This time of year for in-water work would avoid impacts to potential spawning habitat while in use for spawning, and would avoid impacts to all early life stages. Dredging of shoaled material may remove soft substrates, sand, gravel, and small cobbles. However, the same substrate material will remain once maintenance dredging is complete, and will not affect use of the habitat the subsequent season for spawning or rearing.

Deepening and maintenance dredging activities may also impact overwintering habitat for shortnose sturgeon in Reaches B, A-B, and B-C. While overwintering may be temporarily disturbed by these activities, we do not expect alterations to the habitat that would prevent or diminish overwintering in future seasons, as we do not expect changes to habitat features and sediment types to occur. Therefore, we expect effects to shortnose sturgeon spawning and overwintering habitat to be temporary and limited to the final season of blasting and future dredging of shoaled areas within the channel.

7.9.4 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 and Atlantic sturgeon juveniles more prevalent in the low salinity reaches. Concerns have been raised that the proposed deepening could alter the salinity regime in the estuary.

At this stage, the majority of the deepening project is complete. Only a final season of blasting (removing ~25,000 cy; 20 acres) and dredging (~350,000 cy; 100 acres) in Reach B remain.

7.9.4.1 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 percent by weight of the total dissolved ions in seawater, a “salt line” defined by a chlorinity of 250 ppm approximates a salinity of 450 ppm, or 0.45 ppt.

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

To illustrate the variability of salt distribution in the estuary over time, Figure 11 presents a plot of the “salt line” location within Delaware estuary, along with average daily inflow at Trenton, for the period 1 January 1998 through 30 November 2008 (10.9 years). The term “salt line” refers to the 7-day average location of the 250 mg/l (ppm) isochlor (equivalent to 0.45 ppt salinity), and is used as an approximate indicator of the upstream penetration of ocean-derived salinity. In the ~11-year period shown, the salt line has been as far north as RKM 145 in late summer 2005, and at or below RKM 64 during multiple high-flow periods in 2006, a range that exceeds 80 km along the axis of the estuary for a period just over a decade. Figure 12 is a histogram of the daily salt line location for the same January 1998 to November 2008 period, and shows that the average location over this period is about RKM 114, upstream of the Delaware Memorial Bridge and near the mouth of the Christina River in Wilmington, Delaware. Based on monthly averages, the salt line maximum penetration occurs in October (RKM 130) with the minimum in April (RKM 98), reflecting the typical seasonal pattern of freshwater discharge to the estuary. More recently, DRBC (2017) has provided a median range location of the salt front, from RKM 107.8 to RKM 122.3.

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

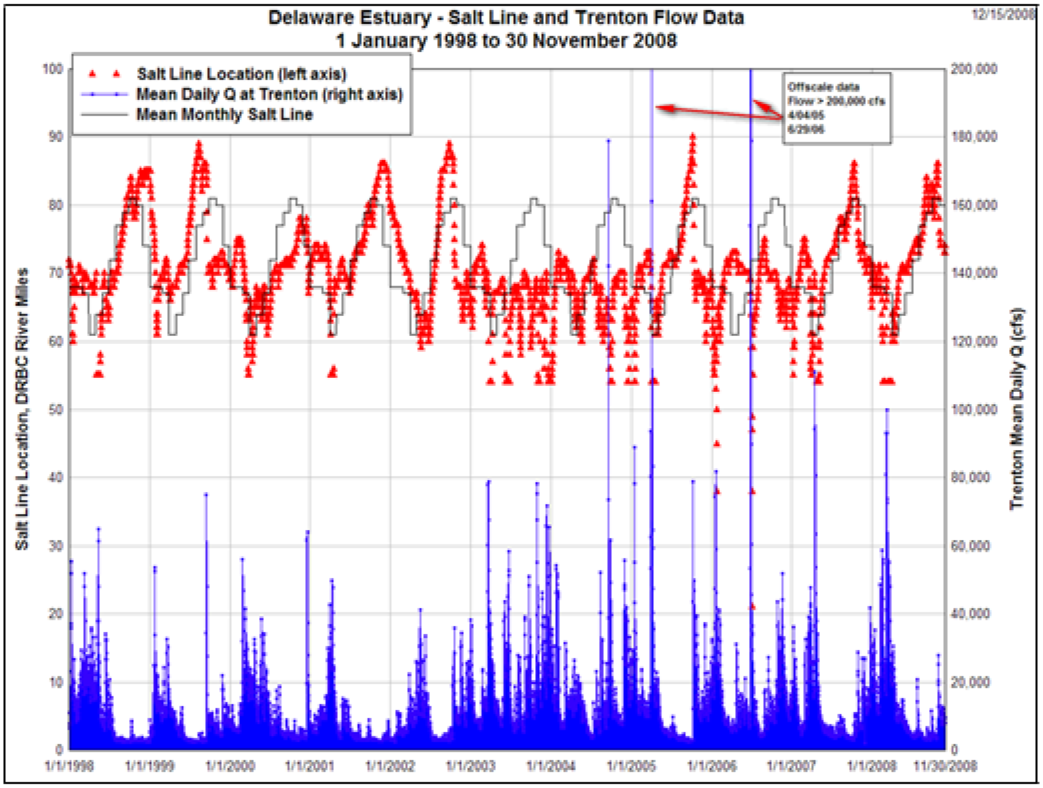
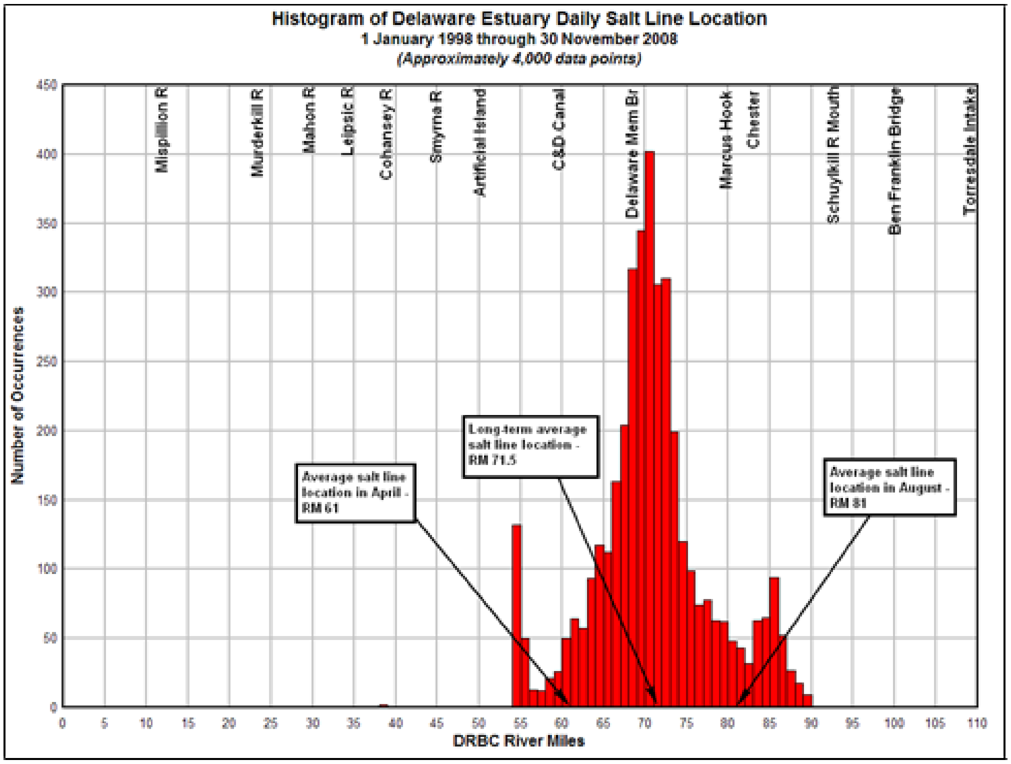


Figure 12: Salt Line Location and Trenton Inflows from 1998 to 2008. (from USACE 2009)


Histogram of Delaware Estuary Daily Salt Line Location
1 January 1998 through 30 November 2008
(Approximately 4,000 data points)

Average salt line location in April - RM 61

Long-term average salt line location - RM 71.5

Average salt line location in August - RM 81

Figure 13: Histogram of Salt Line Location 1998-2008 (from USACE 2009)

7.9.4.2 *<u>Projected Changes in Salinity</u>*

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

In order to estimate the potential for the proposed channel deepening to affect salinity distribution, you 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, you concluded that while deepening would result in salinity increases in the Philadelphia area during a recurrence of the drought of record, these increases would be small. The model estimates that the 10 ppt isohaline, which can fluctuate naturally over a 48 km zone of the estuary, moved upstream an average of from 0.0 to 1.6 km with the deepened channel. The maximum monthly average increase in salinity within the mesohaline zone was 0.1 to 0.3 ppt.

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

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

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

As noted in Section 6, sea level rise combined with more frequent droughts and increased human demand for water has been predicted to result in a northward movement of the salt wedge in the Delaware River (Collier 2011). Currently, the median monthly salt front ranges from RKM 107.8 to RKM 122.3 (DRBC 2017). Collier predicts that without mitigation (e.g., increased release of flows into downstream areas of the river), at high tide in the peak of the summer during extreme drought conditions, the salt line could be as far upstream as RKM 183 in 2050 and RKM 188 in 2100. Collier (2011) predicts that over time, during certain extreme conditions, the salt line could shift up to 18 km further upstream by 2050 and 23 km further upstream by 2100.

Ross *et al.* (2015) details that many factors have an influence on salinity and water quality in an estuary including stream flow, ocean salinity, sea level and wind stress. Ross *et al.* (2015) noted that dredging can also impact salinity, but suggested that dredging at Chester (i.e., increased depth to 45 ft.) has not influenced long-term salinity trends as the statistical models did not detect a significant salinity trend in the area.

7.9.4.3 Effects of Salinity Changes on sturgeon

At this stage of the deepening project, with only one locations (within Reach B) left to be deepened, proposed activities will only make up a minor portion of overall expected changes to salinity levels in the Delaware River.

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 1983a, 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.

Given the availability and location of spawning habitat in the river, it is unlikely that the salt front would shift far enough upstream to result in a significant restriction of spawning or nursery habitat. Shortnose sturgeon spawning habitat (RKM 214-238) is approximately 90 km upstream of the current median range of the salt front (RKM 122). Atlantic sturgeon spawning habitat (RKM 125-212) is at greater risk from encroaching salt water, with some of the best potential spawning habitat at the downstream end of that range (i.e., Marcus Hook Bar area). However, without an upstream barrier to passage, and spawning habitat extending to Trenton, NJ, it is unlikely that salt front movement upstream would significantly limit spawning and nursery habitat. The available habitat for juvenile sturgeon of both sturgeon species could decrease over time; however, even if the salt front shifted several miles upstream, it seems unlikely that the decrease in available habitat would have a significant effect on juvenile sturgeon.

Overall, the effects of remaining deepening on salinity and resulting changes to sturgeon habitat use, above baseline conditions, are too small to be meaningfully measured or detected, and are therefore, insignificant.

7.9.4.4 <u>Effects of Salinity Change on Sea Turtles</u>

Sea turtles occur in saline water. Sea turtles do not occur in the reaches of the river where we expect salinity changes resulting from the deepening project. No impacts to sea turtles from increase in salinity will occur.

7.9.5 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.

You have 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 Oakwood Beach or the DMU sites). 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 Section 7.4, there will be small, short-term increases in suspended sediment and turbidity near where dredging, beach nourishment, and light range construction take place. 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.

7.10 Effects of Proposed Activities on Critical Habitat Designated for the New York Bight DPS of Atlantic Sturgeon

In this analysis, we consider the direct and indirect effects of the action, inclusive of the effects of the Marcus Hook Range Light replacement (an interrelated action) on the four PBFs. For each PBF, we identify those activities that may affect the PBF. For each feature that may be affected by the action, we then determine whether any negative effects to the feature are insignificant, discountable, or entirely beneficial and if not, consider the consequences of those adverse effects. In making this determination, we consider the action's potential to affect how each PBF supports Atlantic sturgeon's conservation needs in the action area. Part of this analysis is consideration of whether the action will have effects on the ability of Atlantic sturgeon to access the feature, temporarily or permanently, and consideration of the effect of the action on the action area's ability to develop the feature over time. Table 24 summarizes the conclusions from Section 5.3.6 on the overlap between dredging reaches, proposed activities, and the four PBFs:

Table 24: Proposed Activity Overlap with Atlantic Sturgeon Critical Habitat PBFs

Physical and Biological Feature (PBF)	**Dredging Reaches and Activities that overlap with PBFs**
PBF 1	Reaches B, A, and AA, all of the Philadelphia to Trenton project (up to RKM 213.5), and the Marcus Hook Range Light project
PBF 2	Reaches D and C
PBF 3	Reaches D, C, B, A, AA, the entire Philadelphia to Trenton project (up to RKM 213.5), and the Marcus Hook Range Light project
PBF 4	Reaches D, C, B, A, AA, the entire Philadelphia to Trenton project (up to RKM 213.5), and the Marcus Hook Range Light project

7.10.1 PBF 1: Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages

In considering effects to PBF 1, we consider whether the proposed action will have any effect on areas of hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages. Therefore, we consider how the action may affect hard bottom substrate and salinity and how any effects may change the value of this feature in the action area. We also consider whether the action will have effects on access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

As explained in Section 5.4.4.1, we consider the area upstream of RKM 107.8 to have salinity levels consistent with the requirements of PBF 1. This stretch of river corresponds to Philadelphia to the Sea Reaches B (RKM 108-136.8), A (RKM 137-156.1), and AA (RKM

156.3-164.2), all of the Philadelphia to Trenton project, and the Marcus Hook Range Light project.

Within the freshwater reaches of the Delaware River that are designated as critical habitat, PBF 1 occurs where there is hard bottom substrate for settlement of fertilized eggs, refuge, growth, and development of early life stages. Those hard bottom areas are only present in parts of the freshwater reach designated as critical habitat. We estimate the freshwater area of critical habitat in the Delaware River (all of which is in the action area) to be 28,436 acres. From tagging and tracking studies, we know that Atlantic sturgeon spawning may occur upstream of the salt front over hard bottom substrate between Claymont, DE/Marcus Hook, PA (Marcus Hook Bar), approximately RKM 125, and the fall line at Trenton, NJ, approximately RKM 212 (Breece *et al.* 2013; Simpson 2008). Within that range, DiJohnson *et al.* 2015 provided evidence for suitable spawning habitat made of outcrops of bedrock and non-depositional, mixed grained material (i.e., hard but not stationary), occurs both within the navigation channel and along the northern edge of the channel near the Eddystone Range (~RKM 133-138).

Activities that overlap with the portion of the Delaware River that contains PBF 1 include: blasting and clean-up dredging to complete the main channel deepening, maintenance dredging in the Trenton to Philadelphia and Philadelphia to the Sea Federal navigation channels, and the Marcus Hook light replacement.

Here we consider whether those activities may affect PBF 1 and if so, whether those effects are adverse, and if not, if the effects are insignificant, discountable or entirely beneficial.

7.10.1.1 Philadelphia to the Sea: Main Channel Deepening:

The areas where rock blasting (removal of ~25,000 cy of material) are required to deepen the channel cover approximately 20 acres of river bottom between RKM 122 and 137 (Reach B). The substrate in this area consists of a combination of bedrock, weathered bedrock, sand, gravel and silts; however, blasting locations are targeting areas of weathered bedrock. Following the completion of the first three seasons of rock blasting, sediment and rocks remaining in the channel were analyzed and compared to the results of vibrocore sampling conducted prior to project initiation. The data show that the substrate remaining in the channel following blasting in 2015 and 2016 still consists of a combination of bedrock, rock fragments, sand and gravel (USACE 2017c). You expect similar results for the proposed additional removal of rock pinnacles by the use of explosives (i.e., the sediment type in the reach will remain unchanged). You do not anticipate that the rock blasting will measurably increase or decrease the amount of hard bottom habitat available to Atlantic sturgeon in the action area. As explained in Section 7.8.4 and below in Section 7.9.4, we do not expect maintenance dredging or the small amount of remaining deepening work in Reaches E and B, to impact salinity levels to an extent that would influence the movement or seasonal location of the salt front or the availability of hard bottom substrate in low salinity waters (PBF 1).

While blasting and cleanup activities will not reduce the amount of hard bottom substrate in the freshwater reach, this habitat will be disturbed during these activities. Blasting activities will only occur between December 1 and March 15. During this period of the year, Atlantic sturgeon spawning does not occur and therefore, there will not be any early life stages (eggs, yolk-sac larvae, post yolk-sac larvae). However, clean-up activities employing a mechanical dredge to remove fragmented rock to achieve the 45-foot depth may occur from July 1, 2019 to March 15, 2020 (or if blasting occur during 2019/2020 season, from July 1, 2020 to March 15, 2021). Therefore, clean-up activities may overlap with the end of the 2019 or 2020 spawning season (July 1 - July 31) as well as a portion of the time when early life stages spawned in 2019 (or 2020) will be present in Reach B, including eggs and yolk-sac larvae (July 1 - August 31), and post yolk-sac larvae (July 1 - September 30).

As discussed in Sections 5.3.2 and 5.4.3, baseline conditions of PBF 1 in the navigation channel vary. We expect some areas of exposed bedrock along the edges of the navigation channel (e.g., the Marcus Hook Bar and Eddystone and Tinicum ranges; ~RKM 125-138) to have a higher likelihood of supporting spawning activity and successful rearing of early life stages, and therefore, a higher conservation value for the species. These areas likely include relatively sheltered interstitial spaces amongst bedrock outcrops, boulders, and large cobble and extend outside of the navigation channel. The fact that these areas have maintained exposed outcrops of bedrock, boulders, and cobbles demonstrates that they are in locations where current and sediment transport keep them clear of soft substrate deposits. These areas are potentially included in areas designated for the final season of blasting and subsequent clean-up dredging. Blasting will occur when PBF 1 is not in use for spawning, and based on the best available information, no spawning habitat area will be lost, and similar substrate will remain following the completion of blasting. Clean-up dredging, however, will occur for one season while spawning is potentially occurring (July 1 – July 31), eggs and yolk sac larvae are present (July 1 – August 31), and when post yolk-sac larvae are present (July 1 – September 30); clean-up dredging will not affect the first three months of spawning or when eggs and yolk-sac larvae (YSL) are potentially present (April 1 – June 30), or the first two months when post-yolk sac larvae (PYSL) may be present (May 1 – June 30). The removal of hard bottom habitat over approximately 20 acres during these times of year will likely temporarily adversely affect the value of PBF 1 for the conservation of Atlantic sturgeon through the removal of substrate supporting fertilized eggs, and the removal of substrate used by larval sturgeon to shelter from predators and higher current velocities. These impacts will only occur from July 2019 to March 2020 (or July 2020 to March 2021) and only over the approximately 20 acres where rock is removed during clean-up dredging.

Based upon the post-blasting sediment sampling from the first two seasons, we expect impacted areas of PBF 1 to completely recover their function and value once blasting and clean-up activities cease (by March 15, 2020 or 2021 depending on when blasting will occur). We reach this conclusion because based on the best available information, we expect the area of hard bottom habitat to remain roughly the same and any changes to the size and distribution of bedrock, boulders, and cobble within the impacted area will be too small to be meaningfully measured or detected. Therefore, the long-term value of the area for sturgeon spawning and rearing of early life stages will not be depreciated.

7.10.1.2 *Philadelphia to the Sea and Philadelphia to Trenton Maintenance Dredging:* Maintenance dredging will occur within the navigation channel where PBF 1 may occur in Reaches B, A, AA, A-B, B-C, and C-D. In these reaches, while maintenance dredging is occurring, we also expect Atlantic sturgeon spawning (June 1 – July 31), the presence of eggs and yolk sac larvae (June 1 – August 31), and post yolk-sac larvae (June 1 – September 30); maintenance dredging will not affect the first two months of spawning or when eggs and yolk-sac larvae are potentially present (April 1 – May 31), or the first month when post-yolk sac larvae may be present (May 1 – May 31).

Maintenance dredging will primarily remove shoaled areas of soft substrates (silts and fine sands) along with occasional dredging of edge shoaling that may have hard substrate (gravel and small cobbles). As described in Table 2, the shoaling areas that represent the vast majority of anticipated maintenance dredging in the navigation channel from Trenton to the sea are all soft substrates. Together, the shoals that occur in the freshwater reaches where PBF 1 may be present are approximately 588 acres, or 2 percent of the freshwater area of critical habitat. You have indicated that the edge shoaling with gravel and small cobbles would be a much smaller area within that larger 2 percent area, and that these areas of edge shoaling do not require frequent dredging (only once every few years). We do not have data to support an estimate of the total area of hard bottom substrate in the freshwater reaches of critical habitat. Based on past decades of maintenance dredging experience, following maintenance dredging events, you expect the same types of substrate to reappear in shoals in approximately the same proportions.

The areas subject to shoaling are dynamic areas that feature unstable sediments that move easily along the riverbed to create shoals. The dynamic nature of these substrates is why maintenance dredging in these shoal areas is required. On a daily basis, we expect large tankers to disturb the bottom sediment of the channel as they pass up and downstream with as little as 2 feet of clearance from the bottom. Shoaled areas that require dredging are a navigation risk for deep draft vessels, meaning that their proximity to direct impacts from prop wash and sedimentation from vessel traffic is very high. As described in Section 5.4.4.1, we do not expect spawning and rearing to occur over shoals in the navigation channel subject to maintenance dredging because the shoals are unlikely to consist of habitats that would be selected by spawning sturgeon. Any gravel and small cobble within shoals are mobile (i.e., there is a lot of movement or shifting of gravels or cobbles), frequently covered by soft sediments, and are disturbed by the natural (e.g., storm events, floods) and anthropogenic (e.g., prop wash) factors. Given these factors, eggs are unlikely to adhere to the substrate and early life stages may be dislodged, buried, entrapped, and/or suffocated. Therefore, substrate in shoaling areas within the navigation channel that are subject to maintenance dredging do not meet the criteria for PBF 1.

Turbidity plumes from maintenance dredging of soft substrates could extend as far as 732m (~2,400 feet) from the dredge, which could also impact hard substrate in areas near the channel during this time frame; however, we expect water velocities that keep hard bottom habitat exposed during pre-activity, baseline conditions and to also be able to remove any sedimentation from turbidity plumes (that we expect to settle out within an hour) before any adverse effects occur. Therefore, effects of sedimentation from dredging turbidity plumes on PBF 1 are extremely unlikely to occur, and are discountable.

7.10.1.3 Marcus Hook Range Lights:

The removal the existing range light structure and installation of the two new range lights will occur in the Marcus Hook area of Reach B between August 1, 2017 to March 15, 2018. All in-water work will occur over bottom substrate with a thick layer of silt (including the 20 square feet of permanent bottom impacts); therefore, the project footprint will have no impact on PBF 1. Sedimentation from mechanical dredging turbidity plumes may affect hard bottom substrate within a 2,000-foot radius (mainly downstream) of the mechanical dredge. However, we expect water velocities that keep hard bottom habitat free of sedimentation during pre-activity, baseline conditions to also be able to remove any sedimentation from mechanical dredging turbidity plumes (that we expect to settle out within an hour); therefore, we do not expect any increase in turbidity to have any effect on the ability of hard bottom substrates adjacent to the range light replacement to support the settlement of eggs or the refuge, growth and development of early life stages of Atlantic sturgeon.

7.10.2 PBF 2: Transitional salinity zone with soft substrate for juvenile foraging and physiological development

In considering effects to PBF 2, we consider whether the proposed action will have any effect on areas of soft substrate within transitional salinity zones between the river mouth and spawning sites for juvenile foraging and physiological development; therefore, we consider effects of the action on soft substrate and salinity and any change in the value of this feature in the action area. We also consider whether the action will have effects on access to this feature, temporarily or permanently. We also consider the effect of the action on the action area's ability to develop the feature over time.

In order to successfully complete their physiological development, Atlantic sturgeon must have access to a gradual gradient of salinity from freshwater to saltwater. Atlantic sturgeon move along this gradient as their tolerance to increased salinity increases with age. PBF 2 occurs from approximately RKM 78 (where the final rule describes the mouth of the river entering Delaware Bay) to approximately RKM 107.8, or the downstream median range of the salt front. As described above, salinity levels in the river are dynamic, and the salt front is defined by a lower concentration (0.25 ppt) than the salinity level of PBF 2 (0.5 ppt), but 107.8 is a reasonable approximation given the lack of real time data and the very small difference we would expect between the area where salinity is 0.5 ppt and 0.25 ppt. As explained in Section 5.4.4.2, we estimate the area of bank to bank critical habitat from RKM 78-107.78 is 29,430 acres, and we estimate that there are 22,980 acres of unconsolidated soft substrates potentially meeting the criteria for PBF 2 within critical habitat in the action area.

Reaches D (RKM 66.1-88.5) and C (RKM 88.7-107.8) contain PBF 2. Within these reaches, USACE has already completed channel deepening to 45 feet. Therefore, the only activity that overlaps with PBF 2 is maintenance dredging of the Philadelphia to the Sea channel. Here we consider whether those activities may affect PBF 2 and if so, whether those effects are adverse and if not, if they are insignificant, discountable or entirely beneficial.

7.10.2.1 Philadelphia to the Sea Maintenance Dredging

Maintenance dredging in Reach C will occur on an annual basis (work window is year-round), while dredging in Reach D (work window is year-round) will occur no more frequently than once every three years. As explained throughout this document, dredging will not occur throughout the entire channel; only shoaled areas will be dredged. The navigation channel in Reaches C and D between RKM 78 and 107.8 is approximately 1,954 acres, or 6.6 percent of the total area of critical habitat in that same range, and 8.5 percent of the area of PBF 2 (assuming all substrate in the navigation channel in RKM 78-107.8 meets the criteria for PBF 2). In Table 2, you describe two shoals made of silt and fine grained sand (New Castle and Deepwater Ranges) that represent the majority of maintenance dredging in these reaches (both occur in Reach C). These shoals meet the substrate and salinity criteria for PBF 2, may require approximately 588 acres of annual maintenance dredging, and are 2.6 percent of the total area of PBF 2. The area of PBF 2 negatively affected the removal of these shoals may be slightly larger than 588 acres, as areas outside of the dredge footprint impacted by sedimentation from the nearfield turbidity plume of hopper dredges may experience a loss of benthic life from burial/suffocation. As explained in Section 7.9.4 and below in Section 7.10.4, we do not expect maintenance dredging in Reaches C or D, or the small amount of remaining deepening work in Reaches E and B, to impact salinity levels to an extent that would influence the movement or seasonal location of the salt front.

You conducted sediment sampling both before and after deepening occurred in Reach B (USACE 2012). These reports confirmed that sediment type was unchanged after deepening. From these reports and past seasons of maintenance dredging in Reaches C and D, you do not anticipate any changes to the substrate type from maintenance dredging (i.e., after removing soft substrates from shoals, similar material will recreate shoals in the same area until they become a navigation hazard and require maintenance dredging again).

Until the areas recover and are repopulated by neighboring colonies of benthic invertebrates, the ability of these shoals to support juvenile foraging and physiological development will be lost. As described above, sturgeon may be exposed to a reduction in forage in the areas where dredging occurs for one to two seasons immediately following dredging (O'Herron and Hastings 1985). As the shoals in Reach C may require annual maintenance dredging, they may never fully recover their value for juvenile foraging and development before being dredged again.

As described in Section 5.3.2, soft substrate within the navigation channel of Reaches D and C may be disturbed on a daily basis by large, deep draft, commercial vessels. Shoals requiring maintenance dredging (such as those in the New Castle and Deepwater Ranges) are particularly vulnerable to disturbance from vessels, as once these shoals build up (which occurs over time after dredging), they are close enough to the keels and propellers of large vessels to be a navigation hazard, and therefore, are highly impacted from prop wash and are sometimes even struck by passing vessels. Given the dynamic nature of the substrates that form these shoals as well as the impacts of natural factors that lead to the creation of these shoals and the disturbance of at least the top layer of sediment when large ships pass overhead, these areas where shoals quickly form may not support as abundant benthic resources as areas outside of the shoals.

These shoaled areas, therefore, may not be of as high value to foraging juvenile Atlantic sturgeon as other areas of soft substrate in the action area. However, given that Atlantic sturgeon forage on a variety of benthic invertebrates, including worms that bury into the substrate, it is not entirely clear what impact this disturbance has on the ability of these shoaled areas to support the foraging and development of juvenile Atlantic sturgeon.

The annual dredging of shoals over 588 acres will negatively affect PBF 2, and will contribute to the feature's inability to improve in value in the future as the repeated removal of substrates to maintain the channel depth will interrupt the establishment and succession of benthic invertebrates in these areas that juvenile Atlantic sturgeon would otherwise feed on. The areas to be dredged represent a small (approximately 2.6% of the area potentially supporting PBF 2) and non-contiguous amount of the available soft bottom substrate within the action area. Not all of these areas will be impacted at any given time. Considering these factors, as well as the naturally dynamic nature of these shoaling areas which may limit their ability to support foraging juvenile Atlantic sturgeon even if dredging did not occur, the effects of annually dredging this small amount of habitat on juvenile foraging or physiological development will be so small that they cannot be meaningfully measured, evaluated, or detected. Therefore, any effects to the value of PBF 2 to the conservation of the species are insignificant.

7.10.3 PBF 3: Water absent physical barriers to passage between the river mouth and spawning sites

In considering effects to PBF 3, we consider whether the proposed action will have any effect on water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: unimpeded movements of adults to and from spawning sites; seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and; staging, resting, or holding of subadults or spawning condition adults. We also consider whether the proposed action will affect water depth or water flow, as if water is too shallow it can be a barrier to sturgeon movements, and an alteration in water flow could similarly impact the movements of sturgeon in the river, particularly early life stages that are dependent on downstream drift. Therefore, we consider effects of the action on water depth and water flow and whether the action results in barriers to passage that impede the movements of Atlantic sturgeon. We also consider whether the action will have effects on access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

Unlike some southern rivers, given the extent of tidal flow, geomorphology and naturally deep depths of the Delaware River, it is not vulnerable to natural reductions in water flow or water depth that can result in barriers to sturgeon movements; we are not aware of any anthropogenic impacts at this time that reduce water depth or water flow in a way that impact sturgeon movements. We are not aware of any complete barriers to passage for Atlantic sturgeon in the Delaware River; that is, we do not know of any structures or conditions that prevent sturgeon from moving up or downstream within the river. There are areas in the Delaware River critical habitat unit where sturgeon movements are affected by water quality (e.g., thermal plumes discharged from power plant outfalls) and noise (e.g., during pile driving at ongoing in-water construction projects); however, impacts on movements are normally temporary and/or intermittent and we expect there always to be a zone of passage through the affected river reach. Activities that overlap with the portion of the Delaware River that contains PBF 3 include the Philadelphia to the Sea Deepening (blasting and dredging) and maintenance dredging, Philadelphia to Trenton maintenance dredging, and the Marcus Hook range light replacement. Here we consider whether those activities may affect PBF 3 and if those effects are adverse, and if not, whether those effects are insignificant, discountable or entirely beneficial.

7.10.3.1 Philadelphia to the Sea Deepening and Maintenance Dredging; Philadelphia to Trenton Maintenance Dredging; Marcus Hook Range Lights:

A study conducted in the James River by Reine *et al.* (2014) found no evidence that would suggest that the presence of an active dredge represented a physical barrier to sturgeon movement. Similarly, the continued construction and ongoing maintenance of the above referenced projects within the Delaware River will not create physical barriers within the river that will impede Atlantic sturgeon movements or use of the river. In areas where the channel is being deepened, the new depth still falls within a range suitable for Atlantic sturgeon use. As stated in other sections, even during times of active dredging, Atlantic sturgeon can still access and use the surrounding area. While some studies indicate that Atlantic sturgeon tend to avoid areas of active dredging (Hatin *et al.* 2007a), other studies (Reine *et al.* 2014) state that Atlantic sturgeon showed neither attraction to nor avoidance of active dredging activities. Moser and Ross (1993) found that both shortnose and Atlantic sturgeon occupied both undisturbed and regularly dredged areas during concurrent dredging operations with no negative impact. As described in Section 7.2, the Barber (2017) and Reine *et al.* (2014) studies showed that sturgeon fish showed no signs of impeded up or downriver movement due to the physical presence of a 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. Brundage (personal communication with USACE, 2017) has noted reduced catches in the Marcus Hook Anchorage when hydraulic dredging was occurring in the adjacent navigation channel. It is not known, however, if the noise produced by pumping the dredged material through the pipeline was causing an avoidance response or if the physical presence of the pipeline and general disturbance of the area may have also contributed to the sturgeon moving away.

Areas subject to blasting, dredging, and the construction of the light ranges will experience localized effects that do not extend across the entire width of the river at any time. These activities overlap with all Atlantic sturgeon life stages where PBF 3 occurs in the action area. However, Atlantic sturgeon (less those injured or killed by blasting or those entrained or captured in the dredges) will still have room to maneuver within the river while avoiding adverse effects from stressors related to project activities. Proposed activities will not prevent adults from migrating to and from spawning sites, nor will they prevent juvenile sturgeon from reaching appropriate salinity zones necessary for foraging and development. Relocation trawling from November 15, to March 15, (2018- 2019 or 2019 to 2020) will remove juvenile Atlantic sturgeon from a winter aggregation area upstream to areas unaffected by blasting activities. This final season of relocation trawling will disrupt juvenile movements within the channel during 14 days of pre-blasting relocation trawling and during a 30-day period of blasting for a few hours each day when relocation and blasting occur. However, once completed, blasting and relocation trawling will not affect or juvenile Atlantic sturgeon's) unimpeded seasonal and physiologically dependent movement to appropriate salinity zones within the river estuary. We do not expect subadults and adults to be present during the time when relocation trawling and blasting will occur. Accordingly, the proposed relocation trawling and blasting in the area will not affect water depth or impede movements of adults.

In sum, the proposed action may have temporary negative effects on PBF 3 by creating in water stressors from construction activities, and extremely small permanent effects by creating minor obstructions in the river (i.e., the Marcus Hook range lights); however, none of the proposed activities will be long term barriers to the movement of adult, subadult or juvenile Atlantic sturgeon. Based on our assessment, these impediments to movement are extremely unlikely to affect the value of PBF 3 to the conservation of the species in the action area; that is, it is extremely unlikely that the habitat alterations that will affect the movement of Atlantic sturgeon in the action area will impede the movement of adults to and from spawning sites or the seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary or impede the staging, resting, or holding of subadults or spawning condition adults; therefore, the effects are discountable.

7.10.4 PBF 4: Water with the temperature, salinity, and oxygen values that, combined, provide for dissolved oxygen values that support successful reproduction and recruitment and are within the temperature range that supports the habitat function

In considering effects to PBF 4, we consider whether the proposed action will have any effect on water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment. Therefore, we consider effects of the action on temperature, salinity and dissolved oxygen needs for Atlantic sturgeon spawning and recruitment. These water quality conditions are interactive and both temperature and salinity influence the dissolved oxygen saturation for a particular area. We also consider whether the action will have effects to access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

As described in Section 5.4.4.4, water quality factors of temperature, salinity and dissolved oxygen are interrelated environmental variables, and in a river system such as the Delaware, are constantly changing from influences of the tide, weather, season, etc. The area with PBF 4 (water between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that combined support spawning, survival, and larval, juvenile, and subadult development and recruitment), may be present throughout the extent of critical habitat designated in the Delaware River (depending on the life stage); therefore, PBF 4 overlaps with Reaches D, C, B, A, AA, the entire Philadelphia to Trenton project, and the Marcus Hook range light project.

Here we consider whether those activities may affect PBF 4 and if those effects will be adverse, and if not, whether those effects are insignificant, discountable or entirely beneficial.

In your 2017 supplemental analysis of Delaware River deepening and maintenance dredging effects on Atlantic sturgeon critical habitat, you determined that proposed activities would not change circulation patterns, velocity, stratification, temperature, hydrologic regime or water level fluctuation (USACE 20017). Only a very small amount of channel deepening to 45 feet remains (20 acres of hard bottom substrate in Reach B, 300 acres of soft substrate in Reach B, and 750 acres of soft substrate in Reach E), and all deepening will be completed by October 2018. Our analysis of remaining project activities on salinity is found in Sections 7.8.4. While deepening would result in salinity increases in the Philadelphia area during a recurrence of the drought of record, these increases would be small. The model estimates that the 10 ppt isohaline, which can fluctuate naturally over a 48 km zone of the estuary, moved upstream an average of from 0.0 to 1.6 km with the deepened channel. The maximum monthly average increase in salinity within the mesohaline zone (area where salinity is 5 to 18 ppt) was 0.1 to 0.3 ppt. Outside of resulting in small increases in salinity in a limited portion of the action area during extreme drought conditions, deepening is not expected to impact salinity in the action area.

Taking into account the information above, many factors influence salinity in the Delaware River, including stream flow, ocean salinity, sea level, wind stress, and human activities (e.g., dredging and deepening activities). Deepening and maintenance dredging in the navigation channel have the potential to affect the spatial and temporal salinity distribution in the action area. However, Ross *et al.* (2015) stated that dredging at Chester (i.e., increased depth to 45 ft.) has not influenced long-term salinity trends (statistical models did not detect a significant salinity trend in the area following completed deepening). While we do expect salt water intrusion further into the Delaware River due to climate change, the relative effects of remaining deepening activities and maintenance dredging on salinity levels and location (spatial and temporal), in addition to baseline conditions, will be too small to be meaningfully measured or detected.

The only way that the proposed dredging and construction impact DO is through increased suspended sediments and turbidity. Sediments suspended during dredging may have minor, temporary, localized effects on DO levels, but we expect sediment to settle out of the water column within an hour before effects would impact the value of the feature for any lifestage of Atlantic sturgeon (also see Section 7.9.5). While remaining deepening activities may have minor effects to the temperature in those sections of navigation channel, the remaining areas requiring deepening are an extremely small portion of the total critical habitat area (less than 1%), and we do not expect any minor changes in temperature to alter how various life stages of Atlantic sturgeon use those respective sections of the river for spawning, rearing, and development.

To summarize, we expect the effects of remaining deepening, future maintenance dredging, and the replacement of the Marcus Hook range lights on the value of PBF 4 to the conservation of the species (i.e., the current and future development of this feature to provide the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment) to be too small to be meaningfully measured or detected, and are therefore, insignificant.

7.10.5 Summary of Effects of Proposed Activities on Atlantic sturgeon Critical Habitat

We have determined that proposed clean-up dredging of blasted material in Reach B will have temporary adverse effects on PBF 1. Effects to PBF 2 and 4 will be so small that they are not able to be meaningfully measured, detected or evaluated and are therefore insignificant. We have determined that effects to PBF 3 are extremely unlikely to occur and are therefore, discountable.

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. Other than those captured in the Status of the Species and Environmental Baseline sections above, 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[23]. The activities discussed in the Cumulative Effects section of the 2011 EA developed for the deepening project – the Paulsboro Marine Terminal and the Southport Marine Terminal require authorization by the US Army Corps of Engineers, therefore they are considered Federal actions and do not meet the definition of “cumulative effects” under the ESA. You have 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.

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

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[23] 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.”

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, we considered potential effects from the following sources: (1) deepening of the Federal navigation channel with cutterhead, hopper, and mechanical dredges; (2) blasting at Marcus Hook and associated debris removal with a mechanical dredge including relocation trawling and acoustic deterrence; (3) maintenance dredging of the navigation channel from Trenton to the sea with cutterhead, hopper, and mechanical dredges; (4) beach nourishment at Oakwood Beach and the DMU sites; (5) installation of the Marcus Hook Range lights; (6) physical alteration of the action area including effects to benthic communities, substrate type, and in salinity in the action area. In addition to these categories of effects, we considered the potential for collisions between listed species and project vessels, the potential for the deepened channel to result in an increase in vessel traffic in the action area and the potential for effects to sturgeon spawning. We anticipate the mortality of a small number of loggerhead and Kemp’s ridley sea turtles, shortnose sturgeon, and Atlantic sturgeon from the five DPSs. Mortality of sea turtles will result from entrainment in hopper dredges operating in the Bay. Mortality of Atlantic and shortnose sturgeon will occur from entrainment in hopper and/or cutterhead dredges and capture during mechanical dredging, blasting during deepening in Reach B, and relocation trawling. As explained in the Section 7.9, clean-up and maintenance dredging are likely to cause adverse effects to the Atlantic sturgeon critical habitat (New York Bight DPS). We do not anticipate any mortality 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. We further consider whether effects of the action will lead to an alteration of the quantity or quality of the essential physical or biological features critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of any listed species in the action area or result in destruction or adverse modification of critical habitat. 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 *et al.* (2016), 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 *et al.* 2016), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

The Delaware River population of shortnose sturgeon is the second largest in the United States. Historical estimates of the size of the population are not available as historic records of sturgeon in the river did not discriminate between Atlantic and shortnose sturgeon. The most recent population estimate for the Delaware River is 12, 047 (95% CI= 10,757-13,580) and is based on mark recapture data collected from January 1999 through March 2003 (ERC Inc. 2006).

Comparisons between the population estimate by ERC Inc. and the earlier estimate by Hastings *et al.* (1987) of 12,796 (95% CI=10,228-16,367) suggests that the population is stable, but not increasing.

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

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Delaware River are affected by impingement at water intakes, habitat alteration, dredging, bycatch in commercial and recreational fisheries, water quality, in-water construction activities, and vessel traffic (e.g., data combined from Delaware's Department of Natural Resources and Environmental Control (DNREC) and reports of recovered carcasses reported to us, indicate that between 2005 and 2016, 92 sturgeon mortalities were attributable to vessel strikes (an additional 47 had an unknown cause of death)). It is difficult to quantify the total 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 cutterhead dredging activities in the 1990s, the shortnose sturgeon killed by hopper dredge in 2017, the shortnose sturgeon killed during the pilot relocation study, and the three shortnose sturgeon killed during blasting (for the deepening project) we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. We also have no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Delaware River since the 1970s when the CWA was implemented, with significant improvements below Philadelphia, which was previously considered unsuitable for shortnose sturgeon and is now well used. Shortnose sturgeon in the Delaware River have full, unimpeded access to their historic range in the river and appear to be fully utilizing all suitable habitat; this suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Salem nuclear power plant occurs occasionally, with typically less than one mortality per year. In high water years, there is some impingement and entrainment of larvae at facilities with intakes in the upper river; however, documented instances are rare and have involved only small numbers of larvae. Bycatch in the shad fishery, primarily hook and line recreational fishing, historically may have impacted shortnose sturgeon, particularly because it commonly occurred on the spawning grounds. However, little to no mortality was thought to occur and due to decreases in shad fishing, impacts are thought to be less now than they were in the past. Despite these ongoing threats, the Delaware River population of shortnose sturgeon is stable at high numbers. Over the life of the action, shortnose sturgeon in the Delaware River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Delaware River population. If the salt line shifts further upstream as is predicted in climate change modeling, the range of juvenile shortnose sturgeon is likely to be reduced compared to the current range of this life stage. However, because there is no barrier to upstream movement it is not clear if this will impact the stability of the Delaware River population of shortnose sturgeon; we do not anticipate changes in distribution or abundance of shortnose sturgeon in the river due to climate change in the time period considered in this Opinion. As such, we expect that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

We have estimated that the proposed activities will result in the following levels of take (for maintenance dredging frequency in all reaches, from Trenton to the sea, refer to Table 1):

- **Dredging**
    - We anticipate that maintenance dredging within Reach A-B, B-C, and the Fairless Turning Basin from June 1 – July 31 will result in entrainment of 1.8% of each year class of shortnose sturgeon post yolk-sac larvae. We do not anticipate that dredging for the deepening will result in loss of shortnose sturgeon early life stages.
    - Between 2018 and 2068, we anticipate the entrainment of 86 sturgeon during all dredging activities from Trenton to the sea (i.e., any combination of shortnose and Atlantic sturgeon or all shortnose sturgeon not exceeding 86 total). The entrainments will occur during the remaining deepening dredging and during the 50 years of future maintenance dredging from Trenton to the sea. Entrainment or capture of shortnose sturgeon may occur in any of the dredge types. Of the 86 sturgeon, we expect that no more than 50 sturgeon (all or a proportion being shortnose sturgeon) will be killed or injured during cutterhead dredging. Further, of the 87 sturgeon, we estimate that five sturgeon (all or some being Atlantic sturgeon) will be killed or injured by mechanical dredging. Interactions with shortnose sturgeon could include juveniles or adults.
- **Blasting**:
    - During the fourth blasting season (December 1, – March 15), we expect that as many as five sturgeon (any combination of shortnose and/or Atlantic sturgeon not exceeding 5 total) will be killed by blasting activities. The shortnose sturgeon could be juveniles or adults.
- **Relocation Trawling**:
    - During relocation trawling in connection with the fourth season of blasting (November 15 – March 15), we expect that as many as 1,841 sturgeon (any combination of shortnose and/or Atlantic sturgeon not exceeding 1,841 total of which up to 50% or 921 can be shortnose sturgeon) will be captured and handled. The shortnose sturgeon could be juveniles or adults.

- During relocation trawling in connection with the fourth season of blasting (November 15–March 15), we expect as many as three sturgeon to be killed (any combination of shortnose and/or Atlantic sturgeon not exceeding 3 total).
- During relocation trawling (November 15, 2017 – March 15, 2018), we expect no more than 1% (9) of shortnose sturgeon captured and handled (up to 921) to be injured (non-lethal).
- During relocation trawling (November 15 – March 15), we expect minor injuries to occur to no more than 100 sturgeon (any combination of shortnose and/or Atlantic sturgeon not exceeding 100 total) from acoustic tagging related surgery.
- As a consequence of relocation trawling (capture, handling, and relocation), seasonal recapture, and multi-season recaptures, we expect up to 15 shortnose sturgeon mortalities.
- As a consequence of relocation trawling (capture, handling, and relocation) and recapture of sturgeon captured during the 2017-2018 season, we expect up to 14 adult shortnose sturgeon females to have reduced fecundity or to postpone reproduction.

Capture during relocation trawling will temporarily disrupt overwintering. However, overwintering behaviors are expected to resume as soon as the fish have reestablished a wintering home range. Captured sturgeon that are tagged will experience minor injury at the tagging site due to handling and surgery. However, recovery is expected to be rapid and occur without any reduction in fitness. Capture and relocation of live shortnose sturgeon will cause stress, depletion of energy resources and a reduction in their condition factor such that their fitness is reduced. The combined effect of capture, handling, tagging and relocation of sturgeon (including multi-year recaptures) during winter is expected to result in the mortality of up to 0.8 percent of the captured sturgeon (any combination of Atlantic sturgeon and shortnose sturgeon). Thus, the proposed project may reduce the numbers of shortnose sturgeon up to fifteen individuals. However, the surviving shortnose sturgeon are expected to increase active foraging once water warms up in spring and the sturgeon are expected to increase their weight and health over the warmer months before the following winter. While the majority of the shortnose sturgeon may not be able to fully compensate for the effects from handling and relocation by the following winter, we do expect their energy reserves to be within the normal range observed in wild sturgeon populations (i.e. they may have lower energy reserves relative to length compared to when captured during relocation trawling but they are expected to have built up enough energy reserves to survive the winter). Thus, no effects to reproduction are anticipated for the shortnose sturgeon captured for the first time. However, since the majority of shortnose sturgeon will not fully regain their energy reserves by the following winter, the capture, handling, and relocation of shortnose sturgeon that were also previously captured during the 2017-18 relocation trawling is likely to result in substantial depletion of energy reserves such that it effects reproduction (reduction in number of eggs or postponed spawning). We expect that in the worst case, up to 14 female shortnose sturgeon in their reproductive cycle may postpone spawning to the following year. The capture of live sturgeon is not likely to affect the distribution of shortnose sturgeon throughout their range.

The number of shortnose sturgeon that are likely to die as a result of the ongoing deepening project and maintenance through 2068 (no more than 103 juveniles or adults (which is an overestimate of impacts as we expect that some of the 103 sturgeon killed will be Atlantics); 1.8 percent of the post-yolk sac larvae (PYSL) from each year class from 2018-2068 when dredging occurs from June 1 – July 31 in Reaches A-B, B-C, and the Fairless Turning Basin), 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 range wide, which is also stable. The best available population estimates indicate that there are approximately 12,047 shortnose sturgeon in the Delaware River (ERC 2006b). While the estimated mortalities associated with proposed activities from now through 2068 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 (adult and juvenile mortalities would be approximately 0.86% of the total population). The effect of this loss is also lessened as it will be experienced slowly over time, with the death of an average of two (1.7) shortnose sturgeon adults or juveniles per year during the next 50 years of maintenance dredging.

Based on the analysis outlined in the "Effects of the Action" section above, 1.8 percent of the post-yolk sac larvae (PYSL) from each year class from 2018-2068 may be killed from when maintenance dredging occurs from June 1 – July 31 in Reaches A-B, B-C, and the Fairless Turning Basin. This estimate assumes that you will dredge frequent shoaling areas (see Table 2) every year, and complete all of the dredging during the time of year when PYSL are present. While you may need to dredge these shoals every year, some may only require dredging every 2-4 years. Also, June 1 – July 31 is only ~ 20 percent of the entire dredging window you have proposed, which extends until March 15, so it is unlikely that all of the dredging will occur when PYSL are present. Early life stages naturally experience high levels of mortality, so the loss of a small percentage of PYSL is not equivalent to the loss of a similar percentage of juveniles or adults. While the loss of PYSL will have an effect on the number of juvenile and eventually the number of adult sturgeon in a particular year class, the reduction in size would be extremely small. As shortnose sturgeon are long lived species, there are up to at least 30 year classes in a population at a particular time. Furthermore, our analysis calculated losses of shortnose sturgeon PYSL in the action area; however, shortnose sturgeon spawn as far upstream as Lambertville, NJ (NMFS and USFWS 1992a, TEWG 2000)RKM 238), meaning 23.5 RKM of potential rearing habitat where PYSL may be present from mid-May through July will be unaffected by the action. Therefore, the estimated loss of 1.8 percent of each PYSL year class from proposed maintenance dredging is likely an extremely conservative estimate.

We conclude that it is unlikely that an extremely small reduction in larval survival would be detectable at the population level. Therefore, the loss of these shortnose sturgeon will not have a detectable effect on the number of shortnose sturgeon in the species as a whole.

Reproductive potential of the Delaware population is not expected to be affected in any other way other than through a one-year reduction in fecundity of up to 14 females and in the 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 103 shortnose sturgeon over a 50-year period at a rate of approximately two per year would affect the success of spawning in any year. The small reduction in the number of male spawners (about half of the sturgeon killed by the proposed action if we assume a 50/50 sex ratio) is not expected to affect production of eggs as enough males will be present to fertilize eggs. Additionally, this small reduction in potential female 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 adversely affect spawning habitat. The only disruption to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds is the one season of relocation trawling (November 15 – March 15) in the Marcus Hook area (when they will be relocated to other overwintering sites upstream). The 14 females that may postpone reproduction or have diminished spawning potential are expected to recover and spawn the following year. We do not expect this activity to prevent or diminish spawning potential in relocated individuals in the future.

The proposed action is not likely to reduce distribution. While the action will temporarily affect the distribution of individual sturgeon by displacing sturgeon captured with the trawl from one area and relocating them to alternate overwintering area, and sturgeon may temporarily avoid areas where dredging, blasting, or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. As the number shortnose sturgeon likely to be killed as a result of the proposed action is extremely small (adults and juveniles killed represent 0.86% of the Delaware River population, in addition to 1.8% of each PYSL year class 2018-2068), there is not likely to be a loss of any unique genetic haplotypes and 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 103 juveniles or adults and 1.8 percent of the PYSL from each year class when dredging occurs from June 1 – July 31 in Reaches A-B, B-C, and the Fairless Turning Basin) from now through 2068, 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 estimated mortality of 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 relocation trawling and movements around the working dredge) and no effect on the distribution of the species throughout its range; and, (5) the action will have no effect on the ability of shortnose sturgeon to shelter and only an insignificant effect on individual foraging shortnose sturgeon.

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

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

The Delaware River population of shortnose sturgeon is stable at high numbers. This action will not change the status or trend of the Delaware River population of shortnose sturgeon or the species as a whole. This is because the reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where deepening and maintenance dredging and blasting will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be insignificant. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area.

The proposed action will not affect shortnose sturgeon outside of the Delaware River. Because it will not reduce the likelihood that the Delaware River population can recover, it will not reduce the likelihood that the species as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.2 Atlantic sturgeon

As explained above, we have estimated that the proposed activities will result in the following levels of mortality (for maintenance dredging frequency in all Reaches, from Trenton to the sea, refer to Table 1):

Early Life Stages

- Following completion of all deepening dredging, the maintenance dredging from Trenton to the sea will result in the mortality of 1.3 percent of each PYSL year class 2019 through 2068 (Table 25).
- The remaining deepening activities (deepening dredging and cleanup dredging) is estimated to result in the mortality of 0.5 percent of the 2019 (or 2020) Atlantic sturgeon YSL year class (Table 25).

- The remaining deepening activities and maintenance dredging of Reach B, A, AA, A-B, and B-C will result in the mortality of 1.55 percent of the 2019 (or 2020) Atlantic sturgeon PYSL year class (Table 25). The estimated percentage includes mortality from the remaining deepening activities (0.25%) and from the maintenance dredging (1.3%).

Table 25. Estimated mortality of YSL and PYSL 2019 year class and each year class from 2019 through 2068 for each dredging activity and dredge types (Mechanical – M, Hopper – H, and cutterhead – C).

Activity	**Dredge type**	**2019**		**2020-2068**	
		YSL	**PYSL**	**YSL**	**PYSL**
Deepening	M, C	0.00	0.21	0.00	0.00
Clean up	M	0.50	0.04	0.00	0.00
Maintenance	M, H, C	0.00	1.30	0.00	1.30
Total		**0.50**	**1.55**	**0.00**	**1.30**

Juveniles and Subadults

- **Dredging**
  - Between 2018 and 2068, we anticipate the entrainment of 86 sturgeon during all dredging activities from Trenton to the sea (i.e., any combination of shortnose and/or Atlantic sturgeon not exceeding 86 total). The entrainments will occur during the remaining deepening dredging and during the 49 years of future maintenance dredging from Trenton to the sea. Entrainment or capture of the Atlantic sturgeon may occur in any of the dredge types. Of the 86 sturgeon, we expect that no more than 50 sturgeon (all or a proportion being Atlantic sturgeon) will be killed or injured during cutterhead dredging. Further, of the 86 sturgeon, we estimate that no more than five sturgeon (all or some being Atlantic sturgeon) will be killed or injured by mechanical dredging. Interactions with the Atlantic sturgeon could include juveniles or subadults. Only mechanical dredging may take (up to 3) adult sturgeon.
- **Blasting:**
  - During the fourth blasting season (December 1 – March 15), we expect that as many as five sturgeon (any combination of shortnose and/or Atlantic sturgeon not exceeding 5 total) will be killed by blasting activities. The Atlantic sturgeon are likely to be juveniles.
- **Relocation Trawling:**
  - During relocation trawling (November 15 – March 15), we expect that as many as 1,841 sturgeon (any combination of shortnose and/or Atlantic sturgeon not exceeding 1,841 total) will be captured and handled. The Atlantic sturgeon are likely to be juveniles.
  - During relocation trawling (November 15 – March 15), we expect as many as three sturgeon to be killed (any combination of shortnose and/or Atlantic sturgeon not exceeding 3 total). The Atlantic sturgeon are likely to be juveniles.
  - During relocation trawling (November 15 – March 15), we expect minor injuries to occur no more than 100 sturgeon (any combination of shortnose and/or Atlantic sturgeon not exceeding 100 total) from acoustic tagging related surgery.

- As a consequence of relocation trawling (capture, handling, and relocation), seasonal recapture, and multi-season recaptures, we expect up to 15 Atlantic sturgeon mortalities.

Combined for all proposed activities, a total of up to 110 juveniles and subadult Atlantic sturgeon will be killed. As detailed in Section 7.10, we do also expect blasting related clean-up dredging to result in temporary adverse effects to PBF 1 (i.e., hard bottom substrate in low salinity waters suitable for settlement of fertilized eggs, refuge, growth, and development of early life stages) of Atlantic sturgeon critical habitat.

9.3 Determination of DPS Composition

We have considered the best available information to determine from which DPSs individuals that will be killed are likely to have originated. Using mixed stock analysis explained above, with the exception of relocation trawling and blasting, which will impact only Atlantic sturgeon from the NYB DPS (due to location and time of year), Atlantic sturgeon exposed to other effects of the proposed action originate from the five DPSs at the following frequencies: NYB 58 percent; Chesapeake Bay 18 percent; South Atlantic 16.5 percent; Gulf of Maine 7 percent; and Carolina 0.5 percent. Given these percentages, we expect that in the worst case that all 86 sturgeon likely to be killed during dredging were Atlantic sturgeon, 50 will originate from the New York Bight DPS, 16 from the Chesapeake Bay DPS, 14 from the South Atlantic DPS, and 6 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.

We expect all 24 of the Atlantic sturgeon killed during blasting, relocation trawling, and relocation to be juveniles originating from the NYB DPS. Juvenile Atlantic sturgeon remain in their natal rivers, and tracking studies indicate that subadult and adult Atlantic sturgeon are not present in the Marcus Hook area during the winter. Also, all eggs, yolk-sac larvae, and post-yolk sac larvae killed will originate from the NYB DPS.

9.4 Gulf of Maine DPS

The GOM DPS is listed as threatened. While GOM DPS Atlantic sturgeon occur in several rivers in the Gulf of Maine, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 7,455 GOM DPS adults and subadults in the ocean (1,864 adults and 5,591 subadults). This estimate is the best available at this time and represents only a percentage of the total GOM DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. GOM origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance (e.g., impingement at water intakes, dredging, bycatch in commercial and recreational fisheries, in-water construction activities, vessel traffic) throughout the riverine and marine portions of their range. While there are some indications that the status of the GOM DPS may be improving, there is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

Based on mixed-stock analysis, we expect that 7 percent of the subadult and adult Atlantic sturgeon in the action area will originate from the GOM DPS. While some adults from the GOM DPS are expected to be present in the Delaware River, we do not anticipate any mortality of adult Atlantic sturgeon from the GOM DPS. We expect that no more than six (6) GOM DPS Atlantic sturgeon will be killed during dredging. This mortality will occur between now and the end of 2068.

The number of subadult GOM DPS Atlantic sturgeon we expect to be killed due to the ongoing project (six between now and the end of 2068) represents an extremely small percentage of the GOM DPS. While the death of six GOM DPS Atlantic sturgeon over this period will reduce the number of GOM DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the GOM DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if there were only 5,591 subadults in the GOM DPS, the loss would represent only 0.11 percent of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of six female subadults would have the effect of reducing the amount of potential reproduction as any dead GOM DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of six male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. The proposed action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how GOM DPS sturgeon use the action area.

Based on the information provided above, the death of no more than six subadult GOM DPS Atlantic sturgeon over 50 years, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of six subadult GOM DPS Atlantic sturgeon represents an extremely small percentage of the population of the DPS; (2) the death of six GOM DPS Atlantic sturgeon will not change the status or trends of the DPS as a whole; (3) the loss of six GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of six subadult GOM DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the DPS; (5) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the DPS throughout its range; and, (6) the action will have only an insignificant effect on individual foraging, migrating, or sheltering GOM DPS Atlantic sturgeon.

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

A Recovery Plan for the GOM DPS has not yet been developed. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for GOM Atlantic sturgeon, individuals must have access to enough habitat in suitable condition for foraging, migrating, resting, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the GOM DPS likelihood of recovery.

This action will not change the status or trend of the GOM DPS as a whole. The proposed action will result in a small amount of mortality over 50 years and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. This project will not affect spawning habitat of the GOM DPS and will have only insignificant and discountable effects on foraging habitat (in the Delaware River and Delaware Bay) used by GOM DPS subadults and adults, and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. We have determined that effects to foraging habitat from loss of prey resulting from dredging are insignificant. Other impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to salinity, temperature, and dissolved oxygen to be insignificant. Once deepening in Reach B is complete, we do not anticipate that any impacts to habitat will impact how sturgeon use the action area.

The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the GOM DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.5 New York Bight DPS

The NYB DPS is listed as endangered. All early life stages (eggs and larvae), young of the year and juvenile Atlantic sturgeon in the action area originate from the Delaware River and belong to the NYB DPS. Based on Mixed Stock Analysis, we expect that 58 percent of the subadult and adult Atlantic sturgeon in the action area will originate from the NYB DPS. NYB origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance (e.g., impingement at water intakes, dredging, bycatch in commercial and recreational fisheries, in-water construction activities, vessel traffic) throughout the riverine and marine portions of their range. As discussed in section 4.7, we have estimated a total of 34,566 NYB DPS adults and subadults in the ocean (8,642 adults and 25,925 subadults). This estimate is the best available at this time and represents only a percentage of the total NYB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. As noted in the Status of the Species and Environmental Baseline section, NYB origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance (e.g., impingement at water intakes, dredging, bycatch in commercial and recreational fisheries, in-water construction activities, vessel traffic) throughout the riverine and marine portions of their range. While there are some indications that the status of the NYB 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.

Over the course of the remaining deepening and maintenance dredging (through 2068), we anticipate the mortality of up to 50 NYB DPS Atlantic sturgeon. These sturgeon could be killed due to entrainment in a hopper or cutterhead dredge, or capture in a mechanical dredge. These fish could be Delaware River origin juveniles, subadult, or adults (no more than three NYB DPS) originating from the Delaware or Hudson River. While it is possible that entrained fish could survive, we assume here that these fish will be killed.

We expect all 23 of the Atlantic sturgeon juveniles killed during blasting, relocation trawling, and relocation to be juveniles originating from the NYB DPS. The 1.3 percent of the egg and yolk-sac larvae (YSL) from the 2018 class killed when clean-up dredging occurs from July 1 – August 30, 2018 in Reach B will originate from the NYB DPS. Lastly, all early life stages killed as a result of remaining deepening and future maintenance dredging in Reaches B, A, AA, A-B, B-C when dredging occurs from June 1 – September 30 (1.55% of the post yolk-sac larvae (PYSL) and yolk-sac larvae (YSL)) from the 2019 (or 2020) Atlantic sturgeon year class, and 1.3 percent of the PYSL from each of the 2020 through 2068 year classes) will be from the NYB DPS, as well.

We anticipate the capture of up to 1,841 NYB DPS Atlantic sturgeon during relocation trawling to be carried out in during the final blasting season (November 15-March, 15). Of these, up to three (3) Atlantic sturgeon juveniles are expected to be killed during relocation trawling, handling, and transport. Captured sturgeon that are tagged (up to 100) will experience minor injury at the tagging site and may experience short term stress due to handling and surgery. However, recovery is expected to be rapid and occur without any reduction in fitness.

Capture and handling during relocation trawling will cause stress responses in the sturgeon and the relocation temporarily disrupt overwintering. Relocation of sturgeon will result in increased activity and potential downstream migration to suitable overwintering habitat. We expect that this will result in increased energy consumption during a time with little feeding such that energy resources are depleted, the relative weight of sturgeon is decreased, and their fitness is decreased. Thus, the combined effect of capture, handling, tagging and relocation of sturgeon during winter is expected to result in the mortality of up to 0.8 percent of the captured sturgeon (any combination of Atlantic sturgeon and shortnose sturgeon). Thus, the proposed project may reduce the numbers of Atlantic sturgeon up to 16 individuals (all juvenile sturgeon). However, the surviving Atlantic sturgeon are expected to resume overwintering behaviors as soon as the fish have returned to suitable overwintering habitat either at the release site or after moving downstream to Marcus Hook reach. The sturgeon are expected to increase active foraging once water warms up in spring and the sturgeon are expected to increase their weight and health over the warmer months before the following winter. While the majority of the Atlantic sturgeon may not be able to fully compensate for the effects from handling and relocation by the following winter, we do expect their energy reserves to be within the normal range observed in wild sturgeon populations (i.e. they may have lower energy reserves relative to length compared to when captured during relocation trawling but they are expected to have built up enough energy reserves to survive the winter).We do not expect relocation to affect long-term survival (i.e. past the winter months) or life time fecundity of surviving sturgeon.

Aside from the lethal take of up to 24 NYB DPS juveniles, the blasting, capture, handling, tagging, and relocation of live sturgeon are not likely to appreciably reduce the numbers of NYB DPS Atlantic sturgeon. Similarly, as the capture of live sturgeon will not affect the long-term fitness of any individual (other than those lethal takes), no appreciable effects to reproduction are anticipated. The capture of live sturgeon is also not likely to affect the distribution of NYB DPS Atlantic sturgeon throughout their range.

While NYB DPS Atlantic sturgeon occur in several rivers in the NYB DPS, spawning has until recently only been documented in the Hudson and Delaware rivers. The capture of age-0 Atlantic sturgeon in the Connecticut River indicates that spawning, at least in some years, is likely occurring in that river as well. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated there to be 34,566 NYB DPS adults and subadults in the ocean (8,642 adults and 25,925 subadults). This estimate is the best available at this time and represents only a percentage of the total NYB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. NYB origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

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

The mortalities estimated from all dredging, blasting, and relocation trawling (up to 73 juvenile, subadult, and adult (no more than three; cutterhead)) Atlantic sturgeon from the NYB DPS over a 50-year period represents a very small percentage of the population (considering the minimum population estimate of 34,566 NYB DPS adults and subadults, this represents 0.16 percent of the population; losses on an annual basis represent an even smaller percentage (less than 0.21%). While the death of these juvenile, subadult, or adult 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).

Based on the analysis outlined in the “Effects of the Action” section above, 0.5 percent of the egg and yolk-sac larvae (YSL) from the 2019 (or 2020) year class will be killed when clean-up dredging occurs from July 1 – August 30 in Reach B. To generate this estimate, we assumed that all Atlantic sturgeon spawning in the Delaware River occurred from RKM 125-138, where substrate mapping and tagging and tracking studies have suggested spawning is likely to occur. This is a very conservative estimate, as the best available information suggests that Atlantic sturgeon spawning may occur where appropriate habitat exists from RKM 125-212; however, substrate data to generate an estimate of spawning habitat over this larger stretch of river are not available. Adverse effects to spawning behavior and lethal take of eggs and YSL from the proposed action are only expected during one season over 20 acres of spawning habitat (~1.3% of the spawning habitat from RKM 125-138). Once deepening and clean-up dredging are complete, this area of habitat will not be affected by this action in the future. We also estimate that remaining deepening and future maintenance dredging in Reaches B, A, AA, A-B, B-C (when dredging occurs from June 1 – September 30) will kill 1.55 percent of the Atlantic sturgeon post yolk-sac larvae (PYSL) from the 2019 or 2020 year class, and 1.3 percent of the PYSL from each year class in 2020 through 2068. This estimate assumes that you will dredge frequent shoaling areas (see Table 2) every year, and complete all of the dredging during the time of year when PYSL are present. While you may need to dredge these shoals every year, some may only require dredging every 2-4 years. Also, June 1 – September 30 is only ~ 40 percent of the entire dredging window you have proposed, which extends until March 15, so it is unlikely that all of the dredging will occur when PYSL are present.

As early life stages naturally experience high levels of mortality, the loss of a small percentage of eggs and YSL (in 2019) and PYSL (2019-2068) is not equivalent to the loss of a similar percentage of juveniles or adults. While these losses of early life stage sturgeon will have an effect on the number of juvenile and eventually the number of adult sturgeon in a particular year class, the reduction in size would be extremely small. As Atlantic sturgeon are long lived species, there are up to at least 30 year classes in a population at a particular time. We conclude that it is unlikely that an extremely small reduction in larval survival would be detectable at the DPS level.

The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of a small percentage of female eggs and larvae (no more than 1.55% from any year class) and up to 73 female non-larval Atlantic sturgeon (could be all juveniles, all subadults, and no more than 3 will be adults) over a 50-year period (average of just over one per year) would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future female spawners (half of the sturgeon killed by the proposed action if assuming a 50/50 sex ratio) is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of a small percentage of male larvae and up to 56 male non-larval Atlantic sturgeon (could be all juveniles, all subadults, and no more than 3 will be adults) may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year.

The proposed action will also not affect the spawning grounds within the Hudson River, nor will it affect any spawning grounds that exist on the Connecticut River. Additionally, we have considered effects of the proposed action on habitat used for spawning in the Delaware River and have determined that there will be adverse effects to hard bottom substrate in low salinity waters (PBF 1 of Atlantic sturgeon critical habitat). However, the 20 acres of spawning habitat adversely affected in 2019 (or 2020) represent only ~1.3 percent of the available surrounding spawning habitat from RKM 125-138, and a smaller percentage of the total area of spawning habitat from RKM 125-212. Following the completion of deepening and clean-up dredging, there will be no long-term adverse effects to spawning habitat (i.e., once blasting and clean-up dredging are complete, we expect there to be the same area of hard bottom substrate with interstitial spaces for spawning and rearing of early life stages), and there will not be any additional delay or disruption of movements to the spawning grounds or to actual spawning. Because of the temporary effects, effects of the proposed blasting and clean up on spawning habitat will not add to effects from blasting and clean up during previous years as those areas now are expected to provide spawning habitat similar to what existed before the blasting occurred.

The proposed action is not likely to reduce distribution because while the action will temporarily affect the distribution of individual sturgeon by displacing sturgeon captured with the trawl from one area and relocating them to alternate overwintering area and sturgeon may temporarily avoid areas where dredging, blasting or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will permanently impact how sturgeon use the action area. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon.

Based on the information provided above, the death of 0.5 percent of the eggs and YSL from the 2019 (or 2020) year class, 1.55 percent of the PYSL from the 2019 (or 2020) year class, and 1.3 percent of the PYSL from each of the 2020 through 2068 year classes, combined with the mortality estimated from dredging, blasting, and relocation trawling (up to 73 juvenile, subadult, and adult (no more than three)) NYB DPS Atlantic sturgeon over a 50-year period, will not appreciably reduce the likelihood of survival of the NYB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these NYB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these NYB DPS Atlantic sturgeon will not result in the loss of any age class; (5) the loss of these NYB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; and (6) the action will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range.

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

A Recovery Plan for the NYB DPS has not yet been developed. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting, migrating, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson or Delaware River populations of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will result in a small amount of mortality over 50 years and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have adverse effects to 20 acres of spawning and rearing habitat (1.3% of the estimated surrounding spawning habitat from RKM 125-138, and a smaller percentage of the total spawning habitat in the Delaware River from RKM 125-212). However, the 20 acres will recover all of their value to the species for spawning and rearing, and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. We have determined that effects to foraging habitat from loss of prey resulting from dredging are insignificant. We do not anticipate the proposed action resulting in any changes to substrate type, and we have determined that any changes to the salinity, dissolved oxygen, and temperature are insignificant. Once deepening in Reach B is complete, we do not anticipate that any impacts to habitat will impact how sturgeon use the action area. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. Because it will not reduce the likelihood that the Hudson or Delaware River population can recover, it will not reduce the likelihood that the NYB DPS as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.6 Chesapeake Bay DPS

Individuals originating from the CB DPS are likely to occur in the action area. The CB DPS has been listed as endangered. We expect that 18 percent of the subadult and adult Atlantic sturgeon in the action area will originate from the CB DPS. CB DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance (e.g., impingement at water intakes, dredging, bycatch in commercial and recreational fisheries, in-water construction activities, vessel traffic) throughout the riverine and marine portions of their range.

Over the course of the remaining deepening and maintenance dredging (through 2068), we anticipate the mortality of up to 16 CB DPS Atlantic sturgeon. These sturgeon could be killed due to entrainment in a hopper or cutterhead dredge, or capture in a mechanical dredge. These fish could be CB DPS subadults or adults (no more than one CB DPS adult mortality is expected from mechanical dredging). While it is possible that entrained/entrapped fish could survive, we assume here that these fish will be killed.

While CB DPS Atlantic sturgeon occur in several rivers, recent spawning has only been documented in the James River and York River systems. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 8,811 CB DPS adults and subadults in the ocean (2,203 adults and 6,608 subadults). This estimate is the best available at this time and represents only a percentage of the total CB DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. CB origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

The number of CB DPS Atlantic sturgeon we expect to be killed due to the ongoing deepening and maintenance (16 over a 50-year period) represents an extremely small percentage of the CB DPS. While the death of 16 CB DPS Atlantic sturgeon over the next 50 years will reduce the number of CB DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the CB DPS population of subadults and an even smaller percentage of the overall DPS as a whole. If all 16 mortalities were subadults and there were only 6,608 subadults in the CB DPS, this loss would represent only 0.23 percent of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

The loss of 16 female subadults, or potentially 15 subadults and 1 adult, would have the effect of reducing the amount of potential reproduction as any dead CB DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of 16 male subadults, or 15 subadults and 1 adult, may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that for any sturgeon that are not killed, any impacts to behavior will be minor and temporary and there will not be any delay or disruption of movements to the spawning grounds or actual spawning. Further, the proposed action will also not affect the spawning grounds within the rivers where CB DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how CB DPS sturgeon use the action area.

Based on the information provided above, the death of no more than 16 CB DPS Atlantic sturgeon over 50 years, will not appreciably reduce the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these CB DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these subadult CB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging, migrating, or sheltering CB DPS Atlantic sturgeon.

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

A Recovery Plan for the CB DPS has not yet been developed. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, migrating, resting, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the CB DPS likelihood of recovery.

This action will not change the status or trend of the CB DPS as a whole. The proposed action will result in a small amount of mortality over 50 years and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. This project will not affect spawning habitat of the CB DPS and will have only insignificant and discountable effects on foraging habitat (in the Delaware River and Delaware Bay) used by CB DPS subadults and adults, and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. We have determined that effects to foraging habitat from loss of prey resulting from dredging are insignificant. Other impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to salinity, temperature, and dissolved oxygen to be insignificant. Once deepening in Reach B is complete, we do not anticipate that any impacts to habitat will affect how sturgeon use the action area. The proposed action will not affect Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the CB DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the CB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.7 South Atlantic DPS

Individuals originating from the SA DPS are likely to occur in the action area. The SA DPS has been listed as endangered. We expect that 17 percent of the subadult and adult Atlantic sturgeon in the action area will originate from the SA DPS. Most of these fish are expected to be subadults, with few adults from the SA DPS expected to be present in the Delaware River. SA DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance (e.g., impingement at water intakes, dredging, bycatch in commercial and recreational fisheries, in-water construction activities, vessel traffic) throughout the riverine and marine portions of their range.

Over the course of the remaining deepening and maintenance dredging (through 2068), we anticipate the mortality of up to 14 SA DPS Atlantic sturgeon. These sturgeon could be killed due to entrainment in a hopper or cutterhead dredge, or capture in a mechanical dredge. These fish could be SA DPS subadults or adults (no more than one SA DPS adult mortality is expected from mechanical dredging). While it is possible that entrained/entrapped fish could survive, we assume here that these fish will be killed.

No total population estimates are available for any river population or the SA DPS as a whole. As discussed in Section 4.7, we have estimated a total of 14,911 SA DPS adults and subadults in the ocean (3,728 adults and 11,183 subadults). This estimate is the best available at this time and represents only a percentage of the total SA DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. SA origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

The number of SA DPS Atlantic sturgeon we expect to be killed (14 subadults, or 1 adult and 13 subadults) due to the ongoing deepening and maintenance the navigation channel from Trenton to the sea represents an extremely small percentage of the SA DPS. While the death of 14 SA DPS Atlantic sturgeon over the next 50 years will reduce the number of SA DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the SA DPS population of subadults and an even smaller percentage of the DPS as a whole. Even if there were only 11,183 subadults in the SA DPS, the loss of up to 14 would represent less than 0.13 percent of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

The loss of 14 female subadults, or potentially 13 subadults and 1 adult, would have the effect of reducing the amount of potential reproduction as any dead SA DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that for any sturgeon that are not killed, any impacts to behavior will be minor and temporary and there will not be any delay or disruption of movements to the spawning grounds or to actual spawning. Further, the proposed action will also not affect the spawning grounds within the rivers where SA DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how SA DPS sturgeon use the action area.

Based on the information provided above, the death of no more than 14 SA DPS Atlantic sturgeon over 50 years, will not appreciably reduce the likelihood of survival of the SA DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect SA DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle or completing essential behaviors including reproducing, foraging and sheltering. This is the case because: (1) the death of these SA DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of these SA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these SA DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these SA DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of SA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging or sheltering SA DPS Atlantic sturgeon.

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

A Recovery Plan for the SA DPS has not yet been developed. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the SA DPS likelihood of recovery.

This action will not change the status or trend of the SA DPS as a whole. The proposed action will result in a small amount of mortality over 50 years and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. This project will not affect spawning habitat of the SA DPS and will have only insignificant and discountable effects on foraging habitat (in the Delaware River and Delaware Bay) used by SA DPS subadults and adults, and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. We have determined that effects to foraging habitat from loss of prey resulting from dredging are insignificant. Other impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to salinity, temperature, and dissolved oxygen to be insignificant. Once deepening in Reach B is complete, we do not anticipate that any impacts to habitat will affect how sturgeon use the action area. The proposed action will not affect SA DPS of Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the SA DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

9.8 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 percent of the Atlantic sturgeon in the action area would originate from the Carolina DPS. However, given the low level of lethal take anticipated (up to 86 over a 50-year period) and the expected rarity of Carolina fish in the action area, it is extremely unlikely that any of the fish that will be killed during the deepening or maintenance will originate from the Carolina DPS. We do not expect any Carolina DPS fish to be present in the action area during the winter months when blasting will occur or when the relocation trawl project will be carried out; therefore, no Carolina DPS fish will be exposed to any effects of those activities. All other effects to Atlantic sturgeon from the Carolina DPS, 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.

9.9 Delaware River Critical Habitat Unit (New York Bight DPS)

We consider the impacts of the proposed actions on the Delaware River Critical Habitat Unit and whether the proposed actions are likely to result in the destruction or adverse modification of critical habitat designated for the New York Bight DPS. On February 11, 2016, NMFS and USFWS published a revised regulatory definition of “destruction or adverse modification” (81 FR 7214). Destruction or adverse modification “means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.” As described in the preamble to the proposed rule for the revised definition (79 FR 27060, May 12, 2014), the ‘‘destruction or adverse modification’’ definition focuses on how Federal actions affect the quantity and quality of the physical or biological features in the designated critical habitat for a listed species and, especially in the case of unoccupied habitat, on any impacts to the critical habitat itself. Specifically, the Services will generally conclude that a Federal action is likely to ‘‘destroy or adversely modify’’ designated critical habitat if the action results in an alteration of the quantity or quality of the essential physical or biological features of designated critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species.

As explained in Section 7.10, all effects of the action on PBFs 2, 3 and 4 are insignificant and discountable. We determined that there will be adverse effects to PBF 1. Here, we consider whether those adverse effects result in a direct or indirect alteration of the critical habitat that appreciably diminishes the value of critical habitat for the conservation of the New York Bight DPS of Atlantic sturgeon.

Adverse effects to PBF 1 are limited to blasting and clean-up dredging that will occur for one year in the period between December 1, and March 15. Annual maintenance dredging activities in Reaches B, A, AA, A-B, and B-C may occasionally encounter small areas of edge shoaling with hard bottom substrate in freshwater and dredging may co-occur with times of year when spawning and rearing of early life stages is occurring. As described in Sections 5.3.6.1 and 7.10.1, we do not expect that these small areas of hard substrate that constitute the edge shoaling will be selected by spawning adults and therefore we do not expect these areas to be used for the settlement of fertilized eggs or the refuge, growth and development of larvae. This is because any gravel and small cobble within shoals are mobile (i.e., there is a lot of movement or shifting of gravels or cobbles), frequently covered by soft sediments, and are disturbed by the natural (e.g., storm events, floods) and anthropogenic (e.g., prop wash) factors. As a result, eggs are unlikely to adhere to the substrate and early life stages may be dislodged, buried, entrapped, and/or suffocated. Additionally, given the dispersed and dynamic nature of any hard substrates within these edge shoals, we do not expect these habitats to be selected by post yolk-sac larvae and therefore, do not anticipate that these habitats would support the refuge, growth or development of this life stage. As such, while these edge shoals may contain hard substrates in low salinity waters, they do not function to support the settlement of fertilized eggs or the refuge, growth or development of early life stages and are therefore not considered to be PBF 1.

Remaining blasting and clean-up dredging required to deepen the navigation channel to 45 feet in Reach B will occur over 20 acres of exposed weathered bedrock, boulders, and cobble within a reach of river (RKM 125-138) where past tagging and tracking studies have indicated high value spawning habitat is present and spawning is likely to occur. We conclude in Sections 7.3 and 7.10.1 that clean-up dredging in Reach B in 2019 (or 2020) will result in the direct removal of hard substrate in freshwater during a time of year when that habitat is supporting the settlement of eggs and rearing of early life stages (eggs, yolk-sac larvae, and post yolk-sac larvae). We concluded that this will result in a reduction in the value of hard bottom substrate in low salinity waters in the action area for the settlement of fertilized eggs and the refuge, growth and development of early life stages (i.e., PBF 1) and that this would be an adverse effect on the designated critical habitat. However, we also note that these adverse effects will be temporary and would only impact the 2019 (or 2020) year class of Delaware River Atlantic sturgeon.

We do not have sufficient data to quantify the full extent (area) of PBF 1 within designated critical habitat for the Delaware River Unit, but available literature suggests that spawning may occur over hard bottom substrates located from RKM 125-212 (an area of 28,436 acres). Clean-up dredging will overlap with spawning during the month of July (25% of the spawning season), and may prevent or deter the hard bottom substrates where clean up dredging will occur (20 acres) from being used for the settlement of fertilized eggs or the refuge, growth and development of early life stages during July 2018. The clean-up dredging may co-occur with

Atlantic sturgeon post yolk-sac larvae (PYSL) from July – September (60% of the time the year class may be present), and will impact the availability and ability of that habitat to support the refuge, growth and development of PYSL in that area during that time period (0.1% of the total area where PYSL may be distributed). We have determined that these habitat impacts will result in the mortality of approximately 0.04 percent of the PYSL from the 2019 (or 2020) year class. Clean-up dredging may co-occur with eggs and yolk sac-larvae (YSL) from July – August 2018 (40% of the time the year class may be present), and will impact approximately 20 acres (1.3% of the total area where eggs and YSL may be distributed in the surrounding area from RKM 125-138). Therefore, in a worst case scenario where spawning only occurred from RKM 125-138 (and not the rest of the river) the habitat impacts would result in the mortality of approximately 0.5 percent of the eggs and YSL from the 2019 (or 2020) year class.

Based upon the post-blasting sediment sampling from the first two seasons, we expect impacted areas of PBF 1 to completely recover their function and value (i.e., the area of PBF 1 in the impacted area will not appreciably change in size or in relative distribution of substrate type) once blasting and clean-up activities cease (by March 15, 2020). Therefore, clean-up dredging's adverse effects on PBF 1's value for the conservation of Atlantic sturgeon is limited to a single season.

In sum, proposed activities will cause adverse effects to 1.3 percent of the total area where PBF 1 may occur from RKM 125-138 for part of one spawning season, with the area's value fully recovering for subsequent seasons. During this affected season, the 20 dredged acres area will provide no conservation value to 0.04 percent of the PYSL year class, and 0.5 percent of the 2019 (or 2020) egg and YSL year class (assuming a worst case scenario that Atlantic sturgeon only spawn from RKM 125-138).

While there will be a decrease in the amount, availability, and function of PBF 1, these impacts are limited only to 2019 (or 2020). By the time Atlantic sturgeon return to use these areas in 2020, the amount, availability, and function of these habitats for the settlement of fertilized eggs and the refuge, growth, and development of early life stages will have returned. Therefore, there will be no permanent reduction in the quantity or quality of PBF 1 in the action area (which encompasses the entire reach of bank to bank river where the feature may be present), as we expect the same area of habitat and relative distribution of hard bottom substrates suitable for spawning to remain after the action is complete.

Therefore, because the temporary adverse effects are confined to a short period of time (July 1 – March 15) in a small area (20 acres or 1.3% of the surrounding spawning habitat and significantly less of the available spawning habitat in the river), the proposed action will not appreciably diminish value of critical habitat for the conservation of the species in the Delaware River critical habitat unit. Alteration of the quantity or quality of the essential physical or biological features of designated critical habitat will not preclude or significantly delay the capacity of the feature (PBF 1) to develop over time, nor will the effects to the feature, or critical habitat in the action area as a whole, appreciably diminish the value of the Delaware River critical habitat unit for the conservation of the species. The action will have no effect on the other critical habitat units designated for the New York Bight DPS including the Connecticut, Hudson and Housatonic river critical habitat units. Therefore, based on the effects of the action on the Delaware River critical habitat unit, and that there will be no effects on the other units designated for the New York Bight DPS, the action will not destroy or adversely modify the critical habitat designated for the New York Bight DPS.

9.10 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.

9.11 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.

9.12 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 maintain or deepen Reach D or E. No interactions with Kemp’s ridleys have been recorded in the deepening and maintenance dredging that has occurred to date. Based on a calculated entrainment rate of sea turtles for projects using hopper dredges in the action area, we estimate that 1 sea turtle is likely to be entrained for every 941,000 cy of material removed with a hopper dredge. Also, based on the ratio of loggerhead and Kemp’s ridleys entrained in other hopper dredge operations in the USACE North Atlantic Division, we estimate that no more than 7 percent 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 40 sea turtles likely to be entrained during the remainder of the deepening and maintenance dredging (through 2068), no more than three (3) are likely to be a Kemp’s ridley; thirty- seven will likely be loggerheads. We expect the three Kemp’s ridley sea turtles to be juveniles, as adults rarely leave the Gulf of Mexico.

Kemp’s Ridley sea turtles are listed as a single species classified as “endangered” under the ESA. Kemp’s ridleys occur in the Atlantic Ocean and Gulf of Mexico. The only major nesting site for Kemp's ridleys is a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; USFWS and NMFS 1992; NMFS and USFWS 2007c).

Nest count data provide the best available information on the number of adult females nesting each year. As is the case with the other sea turtle species discussed above, nest count data must be interpreted with caution given that these estimates provide a minimum count of the number of nesting Kemp's ridley sea turtles. In addition, the estimates do not account for adult males or juveniles of either sex. Without information on the proportion of adult males to females, and the age structure of the Kemp's ridley population, nest counts cannot be used to estimate the total population size (Meylan 1982; Ross 1996; Hawkes *et al.* 2005; letter to J. Lecky, NMFS Office of Protected Resources, from N. Thompson, NMFS Northeast Fisheries Science Center, December 4, 2007). Nevertheless, the nesting data do provide valuable information on the extent of Kemp's ridley nesting and the trend in the number of nests laid. Estimates of the adult female nesting population reached a low of approximately 250-300 in 1985 (NMFS and USFWS 1992a, 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 percent 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 2007c). Nest count data indicate increased nesting and increased numbers of nesting females in the population. We also take into account a number of recent conservation actions including the protection of females, nests, and hatchlings on nesting beaches since the 1960s and the enhancement of survival in marine habitats through the implementation of TEDs in the early 1990s and a decrease in the amount of shrimping off the coast of Tamaulipas and in the Gulf of Mexico in general (NMFS and USFWS 2007c).

The mortality of three juvenile Kemp's ridleys over a 50-year time period represents a very small percentage of the Kemp's ridleys worldwide. Even taking into account just nesting females, the death of two Kemp's ridley represents approximately 0.04 percent of the population. While the death of three Kemp's ridley will reduce the number of Kemp's ridleys compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species or its trend as this loss represents a very small percentage of the population (less than 0.04%). 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 three 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 three juvenile Kemp's ridley sea turtles between now and 2068 will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect Kemp's ridleys in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent Kemp's ridleys from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of three Kemp's ridleys represents an extremely small percentage of the species as a whole; (2) the death of three Kemp's ridleys will not change the status or trends of the species as a whole; (3) the loss of these Kemp's ridleys is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these Kemp's ridleys is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of Kemp's ridleys in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have no effect on the ability of Kemp's ridleys to shelter and only an insignificant effect on individual foraging Kemp's ridleys.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that Kemps ridley sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that Kemp's ridleys can rebuild to a point where listing is no longer appropriate. In 2011, we issued a recovery plan for Kemp's ridleys (NMFS *et al.* 2011). The plan includes a list of criteria necessary for recovery. These include:

1. An increase in the population size, specifically in relation to nesting females[24];
2. An increase in the recruitment of hatchlings[25];
3. An increase in the number of nests at the nesting beaches;
4. Preservation and maintenance of nesting beaches (i.e. Rancho Nuevo, Tepehuajes, and Playa Dos); and,
5. Maintenance of sufficient foraging, migratory, and inter-nesting habitat.

Given the extremely small reduction in numbers, the loss of three Kemp's ridley during the proposed actions (50 years) will not affect the population trend. The number of Kemp's ridleys likely to die as a result of the proposed action is an extremely small percentage of the species. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that criteria one, two or three will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; therefore, the proposed actions will have no effect on the likelihood that recovery criteria four will be met. All effects to habitat will be insignificant and discountable; therefore, the proposed actions will have no effect on the likelihood that criteria five will be met.

The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction. Further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of Kemp's ridleys and a small reduction in the amount of potential reproduction (3 individuals over 50 years), these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual Kemp's ridley sea turtles inside and outside of the actions area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light

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[24] A population of at least 10,000 nesting females in a season (as measured by clutch frequency per female per season) distributed at the primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos) is attained in order for downlisting to occur; an average of 40,000 nesting females per season over a 6-year period by 2024 for delisting to occur

[25] Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos).

of cumulative effects explained above and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to three Kemp's ridley sea turtles between now and 2068, is not likely to appreciably reduce the survival and recovery of this species.

9.13 Northwest Atlantic DPS of Loggerhead sea turtles

In the "Effects of the Action" section above, we determined that loggerheads could be entrained in a hopper dredge working to deepen Reach D or E or in a hopper dredge conducting maintenance dredging activities in either of these reaches. No interactions with loggerhead sea turtles have been observed during deepening or maintenance dredging of the deepened channel to date. Based on a calculated entrainment rate of sea turtles for projects using hopper dredges in the action area, we estimate that one sea turtle is likely to be entrained for every 941,000 cy of material removed with a hopper dredge. Also, based on the ratio of loggerhead and Kemp's ridleys entrained in other hopper dredge operations in the USACE North Atlantic Division, we estimate that 92 percent of the sea turtles entrained during project operations were likely to be loggerheads. Based on this, we determined that of the 40 sea turtles likely to be entrained during the remaining deepening and subsequent maintenance dredging (through 2068), 37 are likely to be loggerheads. Entrained loggerheads may be juveniles or adults. 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. We expect this stable trend to continue over the time period considered in this Opinion (through 2068).

As stated above, we expect the lethal entrainment of 37 loggerheads (could be adults or juveniles) over the 50-year time period considered here; with an average mortality rate of approximately one loggerhead per two years. We would expect the lethal removal of up to 37 loggerhead sea turtles from the action area over this time period 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 2007d). 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 percent of the loggerheads killed, are likely to have originated from the PFRU, with the remainder from the NRU and GCRU. As such, of the 37 loggerheads likely to be killed, 30 are expected to be from the PFRU, with five from the NRU and two 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 2007d). 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 30 loggerheads over a 50-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 30 individuals would represent approximately 0.19 percent of the population. Similarly, the loss of five 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 five individuals would represent approximately 0.4 percent of the population. The loss of two loggerheads from the GCRU, which is expected to support at least 1,000 nesting females, represents less than 0.2 percent 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 50 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.

Loggerheads killed by the proposed action may be adults or 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 37 loggerheads between now and 2068 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 37 loggerheads represents an extremely small percentage of the species as a whole; (3) the loss of these loggerheads is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) 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 rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that loggerhead sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the NWA DPS of loggerheads can rebuild to a point where listing is no longer appropriate. In 2008, we issued a recovery plan for the Northwest Atlantic population of loggerheads (NMFS and USFWS 2008). The plan includes demographic recovery criteria as well as a list of tasks that must be accomplished. Demographic recovery criteria are included for each of the five recovery units. These criteria focus on sustained increases in the number of nests laid and the number of nesting females in each recovery unit, an increase in abundance on foraging grounds, and ensuring that trends in neritic strandings are not increasing at a rate greater than trends in in-water abundance. The recovery tasks focus on protecting habitats, minimizing and managing predation and disease, and minimizing anthropogenic mortalities.

Loggerheads have an increasing trend; as explained above, the loss of 37 loggerheads over 50-years as a result of the proposed actions will not affect the population trend. The number of loggerheads likely to die as a result of the proposed actions is an extremely small percentage of any recovery unit or the DPS as a whole. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that the demographic criteria will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; all effects to habitat will be insignificant and discountable; therefore, the proposed actions will have no effect on the likelihood that habitat based recovery criteria will be achieved. The proposed actions will also not affect the ability of any of the recovery tasks to be accomplished.

In summary, the effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the actions will not prevent the species from growing in a way that leads to recovery and the action will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of loggerheads and a small reduction in the amount of potential reproduction due to the loss of these individuals, these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that loggerhead sea turtles can be brought to the point at which they are no longer listed as threatened.

Despite the threats faced by individual loggerhead sea turtles inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. We have considered the effects of the proposed actions in light of other threats, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above do not change. Based on the analysis presented herein, the proposed 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 our jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is our biological opinion that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon, the GOM, NYB, CB, and SA DPSs of Atlantic sturgeon, Kemp's ridley and loggerhead sea turtles and is not likely to adversely affect Atlantic sturgeon from the Carolina DPS, or green, or leatherback sea turtles. The proposed action may adversely affect, but is not likely to adversely modify or destroy critical habitat designated for the NYB DPS of Atlantic sturgeon.

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. On December 21, 2016, we issued *Interim Guidance on the Endangered Species Term "Harass"*[26]. For use on an interim basis, we interpret "harass" to mean to "…create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering". Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. § 1538(g). See also 16 U.S.C. § 1532(13)(definition of "person"). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to, and not the purpose of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by you so that they become binding conditions for the exemption in section 7(o)(2) to apply. You have a continuing duty to regulate the activity covered by this Incidental Take Statement. If you (1) fail to assume and implement the terms and conditions or (2) fail to require any contractors to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to 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, you 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

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[26] http://www.nmfs.noaa.gov/op/pds/documents/02/110/02-110-19.pdf

Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49). This ITS exempts take for activities that have not yet occurred as of the date of the Biological Opinion.

11.1 Amount or Extent of Incidental Take

The proposed action has the potential to result in the mortality of loggerhead and Kemp's ridley sea turtles, shortnose sturgeon, and individuals from the New York Bight, Gulf of Maine, Chesapeake Bay and South Atlantic DPSs of Atlantic sturgeon due to entrainment in hopper or cutterhead dredges, entrapment in mechanical dredges, relocation trawling, and blasting activities. In this Opinion, we determined that the following levels of take are not likely to jeopardize the continued existence of listed species.

This ITS exempts the following lethal take:

- Northwest Atlantic DPS loggerhead sea turtles:
    - **37** adults or juveniles (hopper dredge entrainment)
- Kemp's ridley sea turtles:
    - **3** juveniles (hopper dredge entrainment)
- Shortnose sturgeon:
    - **86** adults or juveniles (dredging entrainment/entrapment)
        - We expect 86 total lethal sturgeon takes during all dredging activities from Trenton to the sea through 2068 (i.e., any combination of shortnose and/or Atlantic sturgeon not exceeding 86 total)
        - 86 of 86 could result from hopper dredging
        - 50 of 86 could result from cutterhead dredging
        - 5 of 86 could result from mechanical dredging
    - **Post yolk-sac larvae** (dredging entrainment/entrapment)
        - Between 2019 (or 2020) and 2068, we anticipate the entrainment of 1.8% of each year class of shortnose sturgeon post yolk-sac larvae when hopper/cutterhead/mechanical dredges operate within Reach A-B of the navigation channel from June 1 - July 31 in Reaches A-B, B-C, C-D, and the Fairless Turning Basin.
    - **5** adults or juveniles (blasting activities December 1 – March 15)
        - We expect 5 sturgeon takes total from blasting, any combination of shortnose and Atlantic sturgeon (NYB DPS)
    - **3** adults or juveniles (relocation trawling)
        - We expect 3 total sturgeon takes from relocation trawling, any combination of shortnose and Atlantic sturgeon (NYB DPS)
    - **0.8% of sturgeon captured in relocation trawl** or 15 adults or juveniles (indirect mortality from capture, handling and relocation stress)

        - We expect 15 total sturgeon takes from relocation, any combination of shortnose and Atlantic sturgeon.
- New York Bight DPS Atlantic sturgeon:
    - **50** adults, subadults, and juveniles (dredging entrainment/entrapment)
        - We expect 86 total lethal sturgeon takes during all dredging activities from Trenton to the Sea through 2068 (i.e., any combination of shortnose and/or Atlantic sturgeon not exceeding 86 total). Of the 86 possible Atlantic sturgeon takes, 50 will likely be from the NYB DPS.
        - 50 of 50 could result from hopper dredging
        - 29 of 50 could result from cutterhead dredging
        - 3 of 50 could result from mechanical dredging
        - Only mechanical dredging may result in lethal take of 3 adults. We do not exempt any other lethal take of NYB DPS adults.
    - **Eggs and yolk-sac larvae** (dredging entrapment)
        - When clean-up dredging occurs in Reach B from July 1 – August 30, we expect the loss of 0.5% of that egg and YSL year class.
    - **Post yolk-sac larvae** (dredging entrainment/entrapment)
        - When hopper, cutterhead, or mechanical dredging occurs in Reach B, A, AA, A-B, and B-C from June 1 – September 30, we expect dredging entrainment/entrapment to result in the loss of 1.55% of the Atlantic sturgeon PYSL year class in 2019 (or 2020), and 1.3% of each PYSL year class 2020 (or 2021) through 2068.
    - **5** juveniles (blasting activities December 1– March 15)
        - We expect 5 sturgeon takes total from blasting, any combination of shortnose and Atlantic sturgeon (NYB DPS)
    - **3** juveniles (direct mortality during relocation trawling)
        - We expect 3 total sturgeon takes from relocation trawling, any combination of shortnose and Atlantic sturgeon (NYB DPS)
    - **0.8% of sturgeon captured in relocation trawl** or 15 juveniles (indirect mortality from capture, handling and relocation stress)
        - We expect up to 15 sturgeon takes as a consequence of handling stress and relocation of sturgeon, any combination of shortnose and Atlantic sturgeon (NYB DBS)
- Chesapeake Bay DPS Atlantic sturgeon;
    - **16** adults, subadults, and juveniles (dredging entrainment/entrapment)
        - We expect 87 total lethal sturgeon takes during all dredging activities from Trenton to the Sea through 2068 (i.e., any combination of shortnose and/or Atlantic sturgeon not

exceeding 87 total). Of the 87 possible Atlantic sturgeon takes, 16 will likely be from the CB DPS.
    - 16 of 16 could result from hopper dredging
    - 9 of 16 could result from cutterhead dredging
    - 1 of 16 could result from mechanical dredging
    - Only mechanical dredging may result in lethal take of 1 adult. We do not exempt any other lethal take of CB DPS adults.

- South Atlantic DPS Atlantic sturgeon:
  - **14** adults, subadults, and juveniles (dredging entrainment/entrapment)
    - We expect 86total lethal sturgeon takes during all dredging activities from Trenton to the Sea through 2068 (i.e., any combination of shortnose and/or Atlantic sturgeon not exceeding 86 total). Of the 86 possible Atlantic sturgeon takes, 14 will likely be from the SA DPS.
    - 14 of 14 could result from hopper dredging
    - 9 of 14 could result from cutterhead dredging
    - 1 of 14 could result from mechanical dredging
    - Only mechanical dredging may result in lethal take of 1 adult. We do not exempt any other lethal take of SA DPS adults.
- Gulf of Maine DPS Atlantic sturgeon:
  - **6** adults, subadults, and juveniles (dredging entrainment/entrapment)
    - We expect 86 total lethal sturgeon takes during all dredging activities from Trenton to the Sea through 2068 (i.e., any combination of shortnose and/or Atlantic sturgeon not exceeding 86 total). Of the 86 possible Atlantic sturgeon takes, 6 will likely be from the GOM DPS.
    - 6/6 could result from hopper dredging
    - 3/6 could result from cutterhead dredging
    - 1/6 could result from mechanical dredging
    - Only mechanical dredging may result in lethal take of 1 adult. We do not exempt any other lethal take of GOM DPS adults.

This ITS exempts the following non-lethal take:

- New York Bight DPS Atlantic sturgeon:
  - **1,841** sturgeon (relocation trawling)
    - We expect 1,841 sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon) will be captured during the relocation trawling project to be carried out over the blasting season (December 1, 2018 – March 15, 2019 or December 1, 2019 – March 15, 2020). We expect all these to have a short-term reduction in their condition.

    - **100** sturgeon (from surgery to install acoustic tags)
        - Up to 100 of the 1,841 captured sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon) may be injured from surgery to install acoustic tags.
- Shortnose sturgeon
    - **921** sturgeon (relocation trawling)
        - We expect 1,841 sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon of which up to half may be shortnose sturgeon) will be captured during the relocation trawling project to be carried out over the blasting season (December 1, 2018 – March 15, 2019 or December 1, 2019 – March 15, 2020). We expect all these to have a short-term reduction in their condition.
    - **100** sturgeon (from surgery to install acoustic tags)
        - Up to 100 of the 1,841 captured sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon) may be injured from surgery to install acoustic tags.
    - **14** adult females (relocation, multi-season capture)
        - We expect up to 14 tagged females will be recaptures from the previous season (2017/2018) of relocation trawling and will postpone spawning with one year.

11.1.1 Monitoring Incidental Take during Dredging with UXO Screens

We anticipate that interaction with hopper and cutterhead dredges will result in incidental take of sea turtles and sturgeon. An observer is used to monitor the inflow of material from the draghead into the hopper. Screening is placed over the outflow into the hopper such that material with a diameter greater than 4” is captured in a basket. The baskets are inspected and cleaned out following each dredge load. In some instances, overflow screens are also used which prevent large pieces of material from overflowing out of the hopper. When UXO screening is in place on the draghead, the screen prevents any material with a diameter larger than 1.25” from passing through the screen. Thus, if the normal 4x4 screening was used on the outflow into the hopper, any biological material that was small enough to pass through the UXO screen would be small enough to pass through the openings of the intake screen. The use of outflow screening with spacing small enough to trap material with a diameter smaller than 1.25” is not practicable due to issues of clogging and dredge performance. Given these facts, we do not expect an observer to be able to detect any biological material that is small enough to pass through the UXO screens. Therefore, it is not reasonable to require an observer to monitor the inflow or overflow on the dredge when UXO screens are employed. There is no means for an observer to monitor the intake on a cutterhead dredge. Typically, an observer would monitor the disposal site. However, the UXO screening on cutterhead dredges presents similar problems as to those discussed for hopper dredges.

UXO screens will be used when dredging material for the Oakwood beach nourishment project and for the DMU study. You estimate that 33,000 cubic yard of sand will be placed on the

Oakwood beach approximately every eight years. We expect that six beach nourishment events will happen from now until 2068. The sand will be taken from dredging in Reach D. Thus, a total of 188,000 cubic yards will be dredged during the period covered by this Opinion. Either hopper dredge or cutterhead dredge may be used for dredging sand for the Oakwood beach nourishment.

You estimate that 2,780,000 cubic yards of material will be used for initial construction of the DMU study (1,630,000 CY for the Delaware sites and 1,150,000 CY for the New Jersey sites). After completion of the initial construction, you estimated that 400,000 cubic yards of sand would be used for beach nourishment every six years for the Delaware sites and 180,000 cubic yards for the New Jersey sites. You have estimated seven beach nourishment events for both the Delaware and New Jersey sites. Thus, a total of 4,060.000 cubic yards will be used for periodic beach nourishment from now and until 2068 (400,000 CY * 7 = 2,800,000 CY + 180,000 * 7 = 1,260,000). All material for the DMU study will be obtained from maintenance dredging of Reach E. In total, 6,840,000 cubic yards of material will be dredged with the use of UXO screens.

A total of 7,038,000 cubic yards of sand will be dredged for the Oakwood periodic beach nourishment and the DMU study. As explained above, we expect that one turtle will interact with the dredge and be killed for every 941,000 cubic yard removed. Thus, we expect eight sea turtles to interact with the dredge and die when dredging is conducted with an UXO screen mounted on the draghead. Similarly, as explained in Section 7.4, we expect one sturgeon mortality of either species for every 3,350,751 cubic yard of material dredged. Thus, we expect two sturgeon killed during dredging material for beneficial use. The 8 sea turtle takes and 2 sturgeon takes would not be in addition to the lethal take estimated for dredging entrainment, but rather be subtracted from that total.

We have considered whether monitoring of the baskets at the discharge location could serve to monitor take. While we expect that any biological material that passed through the UXO screen would be trapped within the discharge basket, the size of material will still be very small (between 0.75 and 1.25” diameter) and is likely to consist primarily of soft parts which would make detection and identification to species difficult. Additionally, we expect that the UXO screens prevent entrainment of biological material; thus, most interactions would not result in entrainment of body parts. Therefore, while inspection and documentation of material captured in the discharge baskets will provide some information on interactions with listed species, it is not likely to provide an accurate assessment of all interactions with listed species.

During the consultation for the use of sand borrow areas offshore of Delaware and New Jersey for beach nourishment and hurricane protection, the USACE and NMFS considered the following alternatives to monitor take of listed species during dredge operations with UXO screening in place (NMFS 2014).

1. Install a camera near the draghead: A camera installed on a draghead would allow users at the surface to observe underwater interactions. However, there are technical challenges to using video, including visibility due to water clarity and available light, improper

focus, inappropriate camera angle, and the range of the viewing field. The use of video would require additional resources, and it is unlikely that it would be effective for monitoring this type of dredge work. For these dredges, turbidity levels (i.e., up to 450 mg/l) near the draghead while dredging operations are underway are too high to visually detect any animal impinged on or within the vicinity of the draghead. Therefore, this is not a reasonable and appropriate means to monitor take.

2. Use of sonar/fish finder: Sonar can be used to detect animals within the water and within the vicinity of the dredge. However, studies would need to take place to establish the signatures of sea turtles and sturgeon so that they could be readily identified electronically; this information is not currently available. As such, at this time, sonar alone could not indicate the take of an individual animal or identify the species potentially being taken. As such, the use of such devices would not be reasonable or appropriate for monitoring take.

3. Placement of observers on the shoreline: Observers placed on the shoreline may be able to detect stranded animals either in the water or on the shore. However, animals may not strand in the direct vicinity of the operation. Injured or deceased animal may not float to the surface immediately (i.e., it may take days for this to occur) or may drift far from the incident where injury occurred. Therefore, an injured or deceased stranded animal often cannot be definitively attributed to a specific action. The distance between the borrow areas and the shoreline further reduces the viability of this method to monitor take. As such, this is not a reasonable and appropriate means to monitor take.

Both agencies agreed that none of these methods were reasonable or appropriate for monitoring take. We believe that none of these methods would be applicable for monitoring take for the proposed project. In situations where individual takes cannot be observed, a proxy must be considered. This proxy must be rationally connected to the taking and provide an obvious threshold of exempted take that, if exceeded, provides a basis for reinitiating consultation. As explained in Section 7.4 of this Opinion, the estimated number of sea turtles and Atlantic sturgeon to be adversely affected by this action is related to the volume of material removed via dredge, the time of year and the duration of dredging activity.

Therefore, the volume of material removed from the action area can serve as a proxy for monitoring actual take. As explained in the Effects of the Action, we anticipate one sea turtle will be killed for every 941,000 cubic yard of material dredged with a hopper dredge and one Atlantic sturgeon is likely to be killed for every 3,350,751 cubic yard dredged with a hopper or cutterhead dredge. This estimate provides a proxy for monitoring the amount of incidental take during dredging operations when UXO screening is in place and direct observations of interactions cannot occur. This will be used as the primary method of determining whether incidental take has occurred; that is, we will consider that one sea turtle has been taken for every 941,000 cubic yard material removed during hopper dredging operations. Similarly, we will consider that one subadult Atlantic sturgeon has been taken for every 3,350,751 cubic yard of material removed during hopper or cutterhead dredging operations. There is a possibility that a sea turtle or an Atlantic sturgeon may remain impinged on UXO screens after the suction has been turned off. These animals can be visually observed, via a lookout, when the draghead is lifted above the water. Animals documented on the draghead by the lookout will be considered a take and this monitoring will be considered as a part of the monitoring of the actual take level. Monitoring of the discharge cages will also be used as part of the monitoring. Similarly, should we receive any reports of injured or killed sea turtles or sturgeon in the area (i.e., via the STSSN) and necropsy documents that detail interactions with the hopper dredge operating during this project was the cause of death, we will consider those animals to be taken by these activities.

As soon as the estimated number of sea turtles are observed or believed to be taken (e.g., if the total was eight turtles: eight takes via proxy or two observed impinged and six via proxy, etc.), any additional entrainment of a sea turtle will be considered to exceed the exempted level of take. We expect exceedance of the exempted amount of take to be unlikely given the conservative assumptions made in calculating this estimate. Lookouts will be present on the vessel and volumes of material removed will be continuously monitored during dredge operations. Further, the volume of sand needed for beach nourishment are estimated cubic feet and the actual volume of sand needed may be less or more. The USACE will provide us annual reports of the volume used for beneficial uses and an assessment of the volume of material to be removed at the next beach nourishment cycle, which will provide an early indication of whether an exceedance of take is likely to occur. Additionally, the monitoring of the discharge baskets provides a means for collecting and identifying any biological material that is entrained on the dredges. Therefore, take levels can be detected and assessed early in the project and, if needed, consultation can be reinitiated.

We will consider incidental take exceeded if the following condition is met:

- Reported take from cutterhead and hopper dredging without UXO screens as well as mechanical dredging together with estimated (based on volume dredged) and observed take from dredging with a UXO screen in place exceeds 38 loggerhead sea turtles, 3 Kemp’s ridley sea turtles, or 86 sturgeon (shortnose sturgeon, Atlantic sturgeon, or a combination of the two species).

11.1.2 Lethal Take of Sturgeon Early Life Stages

We considered several methods to monitor the validity of our estimates that dredging activities (summarized above) will result in the lethal take of 0.5 percent of the Atlantic sturgeon egg and yolk-sac larvae year class in 2019 or 2020; 1.55 percent of the Atlantic sturgeon post yolk-sac larvae year class in 2019 or 2020; 1.3 percent of each Atlantic sturgeon post yolk-sac larvae year class from 2020 (or 2021) through 2068; and 1.8 percent of each shortnose sturgeon post yolk-sac larvae year class from 2019 or 2020 through 2068.

We considered requiring monitoring for early life stage sturgeon (i.e., eggs and larvae) aboard hopper dredges (i.e., where observers currently monitor take of sturgeon and sea turtles) and in the disposal areas (e.g., dredge material scows, confined disposal facilities); however, because of the size of both species of sturgeon at these life stages (~2-57mm, depending on the species and early life stage), the sturgeon would be too small to reliably observe and quantify.

We also considered requiring pre- and post-dredging surveys of areas to be dredged during the times of year when we would expect early life stages to be present. However, again, the sturgeon larvae are extremely small and hard to reliably find and quantify. Also, just because the sturgeon are not in the dredge area during the survey, that does not mean they will not enter the dredge area (e.g., foraging post yolk-sac larvae) during dredging activities.

For either of these methods we considered, even if we were able to reliably quantify the take of sturgeon early life stages from dredging, we would need an estimate of the total number of sturgeon in that year class in the Delaware River to validate our estimates of the percentage of each year class killed from dredging activities. These data are not available at this time, and we are not aware of any feasible methodology that could be carried out to collect such data.

Because the monitoring methods considered above are neither reasonable and prudent nor necessary or appropriate, we will use a means other than counting individuals to monitor the estimated numerical level of take and provide a means for reinitiating consultation once that level has been exceeded.

For this action, the areas you have proposed to deepen and maintain in the freshwater reaches of the action area between June 1 and September 30 of any given year provide a proxy for monitoring the actual amount of incidental take of eggs, yolk-sac larvae, and post yolk-sac larvae that we anticipate.

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

1. Clean-up dredging of blasted material in Reach B (part of the deepening project) exceeds 20 acres between July 1, 2019 (or 2020) and September 30, 2020 or 2021 respectively.
2. Deepening in Reach B exceeds 100 acres between July 1, 2019 (or 2020) and September 30, 2020 (or 2021 respectively).
3. Maintenance dredging in Reaches B, A, AA, A-B, or B-C exceeds 588 acres between June 1 and September 30 of any year between 2019 and 2068.
4. Construction activities (e.g., dredging, blasting) occur in Reaches B, A, AA, A-B, B-C, or C-D (i.e., RKM 107.8-214.5) outside of the time of year you proposed to work (detailed in Table 1), while early life stage sturgeon may be present (i.e., between June 1 and September 30 of any year).

11.2 Reasonable and Prudent Measures, Terms and Conditions, and Justifications

We believe the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize and monitor impacts of incidental take resulting from the proposed action. In order to be exempt from prohibitions of section 9 of the ESA, you 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.

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 you 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 third column 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 you.

Table 26. RPMs, TCs, and Justifications

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
RPMs Applicable for All Activities		
1. All sturgeon captures, injuries, or mortalities in the immediate activity area must be reported to us within 24 hours.	1. In the event of any captures or entrainment of Atlantic sturgeon (lethal or non-lethal), you must follow the Sturgeon Take Standard Operating Procedures (SOPs) found at: www.greateratlanticfisheries.noaa.gov/protected/section7/reporting.html). The SOP is also enclosed as Appendix B. You must submit a completed Take Report Form for ESA-Listed Species within 24 hours of any take. The form can be downloaded from our website[27] and is also enclosed as Appendix C. The completed Take Report Forms, together with any supporting photos or videos must be submitted to incidental.take@noaa.gov with "Take Report Form" in the subject line. 2. In the event of any lethal takes of Atlantic sturgeon, any dead specimens or body parts must be photographed, measured, and preserved (refrigerate, not freezed) until disposal procedures are discussed with us.	These RPMs and TCs are necessary and appropriate to ensure the 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. In some cases, when the cause of death is uncertain, a necropsy may be necessary to aid in the determination of whether or not a mortality should count toward the ITS. This is essential for monitoring the level of incidental take associated with the proposed action. These RPMs and TCs represent only a minor change as compliance will not delay of the project or decrease in the efficiency of the dredging operations.

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[27] https://www.greateratlantic.fisheries.noaa.gov/protected/section7/reporting.html

Reasonable and Prudent Measures (RPMs)	**Terms and Conditions (TCs)**	**Justifications for RPMs & TCs**
2. Any dead sturgeon must be held until proper disposal procedures can be discussed with us. The fish should be held in cold storage.	3. In the event you collect or capture a dead sturgeon (e.g., dead sturgeon incidentally collected during dredging, blasting, or relocation trawling in the Delaware River Navigation Channels) and you request concurrence that this take should not be attributed to the Incidental Take Statement but we do not concur, or if it cannot be determined whether a proposed activity was the cause of death, then the dead sturgeon must be transferred to an appropriately permitted research facility identified by us so that a necropsy can be undertaken to attempt to determine the cause of death. The form included as Appendix D (sturgeon salvage form) must be completed and submitted to us. 4. NMFS will have the mortality assigned to the incidental take statement if the necropsy determines that the death was due to injuries sustained from an interaction with dredge gear or exposure to blasting. We shall have the final say in determining if the take should count towards the Incidental Take Statement.	
3. All Atlantic sturgeon over 75 cm total length that are	5. You must ensure that fin clips are taken (according to the procedure outlined in	These RPMs and TCs are necessary and appropriate to

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
captured (dead or alive) must have a fin clip taken for genetic analysis. This sample must be transferred to a NMFS-approved laboratory capable of performing the genetic analysis.	Appendix E) of any Atlantic sturgeon over 75 cm captured during the project (including relocation trawling) and that the fin clips are sent to a NMFS approved laboratory capable of performing genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies. To the extent authorized by law, you are responsible for the cost of the genetic analysis.	ensure the proper handling and documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. This is essential for monitoring the level of incidental take associated with the proposed action. Genetic analysis must be conducted on Atlantic sturgeon samples to determine the appropriate DPS of origin and accurately record take of this species. These RPMs and TCs represent only a minor change as compliance will not result in delay of the project or decrease in the efficiency of the dredging operations.
4. All sea turtle captures, injuries, or mortalities and any sea turtle sightings in the immediate dredging area must be reported to us within 24 hours.	6. In the event of any captures or entrainment of sea turtles (lethal or non-lethal), you must follow the Sea Turtle Take Standard Operating Procedures (SOPs) found at: www.greateratlanticfisheries.noaa.gov /protected/section7/reporting.html). The SOP is also enclosed as Appendix F.	These RPMs and TCs are necessary and appropriate to ensure the 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. In some cases, when the cause of death is

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	7. You shall report the take within 24 hours. A Take Report Form for ESA-Listed Species must be completed and submitted to us. The form can be downloaded from our website[28] and is also enclosed as Appendix C. We shall have the final say in determining if the take should count towards the Incidental Take Statement. 8. If the cause of death is unknown, dead sea turtles found along the shores of the Delaware Bay (e.g., beaches) within two weeks of when dredge operations occurred in the Delaware River Navigation Channels and in an area where the carcass reasonably could have drifted from dredge operations, will have the mortality assigned to the incidental take statement if a necropsy determines that the death was due to injuries sustained from an interaction with dredge gear (using the process outlined in Appendix G, the November 27, 2017, stranding/dredge take memo). Sea turtle injuries consistent with hopper dredge interactions may include: - crushing wounds/injuries; - partial carapace or body part;	uncertain, a necropsy may be necessary to aid in the determination of whether or not a mortality should count toward the ITS. This is essential for monitoring the level of incidental take associated with the proposed action. These RPMs and TCs represent only a minor change as compliance will not result in delay of the project or decrease in the efficiency of the dredging operations

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[28] https://www.greateratlantic.fisheries.noaa.gov/protected/section7/reporting.html

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	- jagged edges to injury; - internal organs completely or partially missing or displaced; - excoriated skin injuries; or - peeling or missing scutes, not related to decomposition, around injury area	
5. Any dead sea turtles must be held until proper disposal procedures can be discussed with us. Turtles should be held in cold storage.	9. In the event of any lethal takes of sea turtles, any dead specimens or body parts must be photographed, measured, and preserved (refrigerate or freeze) until disposal procedures are discussed with us. If a decomposed turtle or turtle part is captured or 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 you anticipate that they will not be counted towards the ITS) must be frozen. You must ensure that the observer submits the incident report for the decomposed turtle part, as well as photographs, to us within 24 hours of the take (see Appendix C) and request concurrence that this take should not be attributed to the Incidental Take Statement. If we do not concur or if it cannot be determined whether entrapment in a dredge	These RPMs and TCs are necessary and appropriate to ensure the 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. In some cases, when the cause of death is uncertain, a necropsy may be necessary to aid in the determination of whether or not a mortality should count toward the ITS. This is essential for monitoring the level of incidental take associated with the proposed action. These RPMs and TCs 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

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	was the cause of death, then the turtle or turtle parts shall be transported to a nearby stranding or rehabilitation facility for review. We shall have the final say in determining if the take should count towards the Incidental Take Statement.	
RPMs Applicable for All Dredge Activities		
6. We must be contacted prior to the commencement of dredging and again upon completion of the dredging activity.	10. You must contact us at incidental.take@noaa.gov 3 days before the commencement of each dredging activity and again within 3 days of the completion of the activity. This correspondence will serve both to alert us of the commencement and cessation of dredging activities and to give us an opportunity to provide you with any updated contact information or reporting forms. At the start of dredging activities, you must include the total volume and area you anticipate removing, the Reach where dredging will occur (with RKMs) and the type of dredge to be used. At the end of the dredging event, you must report to us the actual volume and area removed, location where dredging occurred (with RKMs), and	These RPMs and TCs are necessary and appropriate because they serve to ensure that we are aware of the dates and locations of all dredging that may result in take. This will allow us to monitor the duration and seasonality of dredging activities as well as give us an opportunity to provide you with any updated species information or contact information for our staff. This is only a minor change because it is not expected to result in any delay to the project and will merely involve occasional e-mails between you and our staff.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	the equipment used (type of dredge).	
7. All dredges must be operated in a manner that will reduce the risk of interactions with listed species.	11. 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 as determined by the line of sight from the vessel bridge.	These RPMs and TCs 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.
RPMs Applicable for All Hopper Dredges		
8. You shall ensure that all 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.	12. All hopper dredges must be equipped with the rigid deflector draghead as designed by your 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 installation and operation during dredging. The deflector	These RPMs and TCs are necessary and appropriate as the use of draghead deflectors is accepted standard practice for hopper dredges operating in places and at times of year when sea turtles are known to be present and has been documented to reduce the risk of entrainment for sea turtles, thereby minimizing the potential for take

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	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.	of these species. This represents only a minor change as all of the hopper dredges likely to be used for this project, including the 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.
RPMs for when UXO Screening Not In Place on Hopper Dredge		
9. For all hopper dredge operations where UXO screening is not in place, a NMFS-approved observer must be present on board the hopper dredge any time it is operating. You shall ensure that dredges are equipped and operated in a manner that provides endangered/threatened species observers with a reasonable	13. You 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 the Monitoring Specifications for Dredges (Appendix H). 14. When UXO screening is not in place, observer coverage on hopper dredges must be sufficient for 100% monitoring of hopper	These RPMs and TCs are necessary and appropriate because they require that you 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

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
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.	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. You must ensure that your 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 H). No observers can be deployed to the dredge site until you have written confirmation from us that they have met the qualifications to be a "NMFS-approved observer" as outlined in Appendix H. If substitute observers are required during dredging operations, you must ensure that our approval is obtained before those observers are deployed on dredges. 15. You shall require of the dredge operator that, when the observer is off watch, the cage shall not be opened unless it is clogged. You 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 he/she	TCs is only a minor change as you included some level of observer coverage in the original project description and the increase in coverage (i.e., the addition of any months/activities that were not previously subject to observer coverage) 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.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	returns on duty. In addition, the observer shall be the only one allowed to clean off the overflow screen.	
10. You shall ensure that all measures are taken to protect any turtles or sturgeon that survive entrainment in a hopper dredge.	16. The procedures for handling live sea turtles must be followed in the unlikely event that a sea turtle survives entrainment in the dredge (Appendix I). Any live sturgeon must be photographed, weighed and measured if possible, and released immediately overboard while the dredge is not operating. You must make arrangements with a NMFS-approved facility that agrees to receive any sea turtles injured during dredging. This arrangement must include procedures for transferring these turtles to the care of the facility. To the extent authorized by law, arrangements must address funding of any necessary care and/or rehabilitation. This plan must be developed in cooperation with our Sea Turtle Stranding Coordinator and is subject to approval by us. This plan must be in place and approved before December 31, 2019.	These RPMs and TCs are necessary and appropriate as they will require that dredge operators use best management practices that will minimize the likelihood of take. This represents only a minor change as following these procedures should not result in any delays of reduction of efficiency of the dredging project. Further, they are necessary and appropriate to ensure that any sea turtles or sturgeon that survive entrainment in a hopper 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 any delays to the proposed project.
RPMs for UXO Screening on Hopper Dredge		

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
11. You shall ensure that for all dredge operations where UXO screening is in place, a lookout/bridge watch, knowledgeable in listed species identification, will be present on board the hopper dredge at all times to inspect the draghead each time it is removed from the water.	17. The lookout will inspect the draghead for impinged sea turtles or Atlantic sturgeon each time it is brought up from completing a dredge cycle. Should a sea turtle or Atlantic sturgeon be found impinged on the draghead, the incident should be recorded (Appendix C) and we must be contacted within 24 hours.	These RPMs and TCs are necessary and appropriate to ensure the 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. These RPMs and TCs 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.
RPMs for UXO Screening on Hopper or Cutterhead Dredge		
12. For all hopper or cutterhead dredge operations where UXO screening is in place, you shall provide monthly reports to us regarding the status of dredging and interactions or observations of listed species.	18. You will provide us with reports every 30 days, via email (peter.b.johnsen@noaa.gov and incidental.take@noaa.gov) recording the days that dredging occurred, summaries of the bridge watch reports on draghead inspection, the volume of material removed during the previous 30-day period and any observations of listed species.	These RPMs and TCs are necessary and appropriate to ensure the 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

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
		the proposed action. These RPMs and TCs 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.
RPMs for when UXO Screening Not in Place on Cutterhead Dredge		
13. Prior to finalizing contract specifications and initiating contract solicitation processes for new cutterhead dredging projects, you must work with us to develop monitoring plans for cutterhead dredges and/or dredged material disposal sites.	19. You will schedule a meeting with us prior to finalizing contract specifications and initiating contract solicitation processes for new cutterhead dredging projects to determine the scope of a monitoring plan. This monitoring plan must be agreed to by us prior to initiation of contracting processes and must be implemented in all subsequent cutterhead dredge contracts, unless modified by agreement of USACE and NMFS. The goal of the monitoring plan will be to accurately determine entrainment of Atlantic sturgeon in future cutterhead dredging projects when no UXO screening is in place; however, physical screening of dredge material by observers is not required.	These RPMs and TCs are necessary and appropriate as they serve to ensure that sturgeon have a minimized risk of injury or mortality from cutterhead dredging activities when UXO screening is not in place. The monitoring plan represents only a minor change as it will not result in any significant delays to dredging or significant modifications of the dredge plan and any increased cost will be very small in comparison to the total costs of the project or changes to dredging operations.
RPMs for Mechanical Dredging		
14. A lookout/bridge watch must	20. For mechanical dredging you must require	These RPMs and TCs are

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
be present to observe all mechanical dredging activities where dredged material will be deposited for any capture of sturgeon.	a lookout to watch for captured sturgeon in the dredge bucket and to monitor the scow/hopper for sturgeon. Any interactions with sturgeon must be reported to us.	necessary and appropriate because they require that you 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 TCs is only a minor change as you included some level of observer coverage in the original project description and the increase in coverage (i.e., the addition of any months/activities that were not previously subject to observer coverage) 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.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
15. You must ensure that all measures are taken to protect any sturgeon that survive capture in the mechanical dredge.	21. Any sturgeon observed in the dredge scow/hopper during mechanical dredging operations must be removed with a net and, if alive, returned to the water away from the dredge site.	These RPMs and TCs are necessary and appropriate to ensure that any sturgeon that survive capture in a mechanical dredge are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality through inappropriate handling. This represents only a minor change as following these procedures will not result in an increase in cost or any delays to the proposed project.
RPMs Related to Blasting		
16. Acoustic measurement of the first three detonations must be conducted to confirm your estimated underwater pressure levels. If pressure levels exceed those estimated in the monitoring plan, you must contact us within 24 hours of the recorded measurement.	22. Acoustic measurement of the first three detonations must be conducted to confirm your estimated underwater pressure levels (i.e., noise levels below 206dB (or the psi equivalent) at 500 feet). Results of this monitoring must be reported to us prior to any subsequent blasting. This acoustic monitoring must be repeated for a representative sample of all blasts (occurring on at least one day per month during the blasting season). If you determine that 206dB are being exceeded outside of the 500-foot blast radius,	These RPMs and TCs are necessary and appropriate to minimize the potential for blasting activities to take place when sturgeon are within 500 feet of the detonation site. These conditions are also designed to verify that the sound and pressure levels presented by you and that we rely on in estimating take are valid and that a 500-foot exclusion zone is sufficient. This does not cause more than minor

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	sturgeon protection measures must be expanded to include a radius that encompasses all areas where noise/pressure levels are expected to exceed 206dB.	changes because it merely provides additional clarification to the requirement already imposed by you to conduct underwater monitoring of pressure levels associated with blasting. The monitoring plan represents only a minor change as the plan to be implemented will be designed by you 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.
17. You must implement the NMFS-approved monitoring plan to minimize sturgeon exposure to blasting and ensure that any sturgeon killed during blasting are recorded.	23. NMFS approved the monitoring plan for minimizing adverse effects of blasting and relocation trawling prior to the first blasting season in 2015. Aside from the removal of steps using a DIDSON camera, all other protection measures must remain in place. If lethal take for blasting and relocation trawling exceeds the number (8) outlined in the ITS of this Opinion, a new plan must be approved before blasting may continue.	These RPMs and TCs are necessary and appropriate as they serve to ensure that sturgeon have a minimized risk of injury or mortality from blasting and relocation trawling activities. The monitoring plan represents only a minor change as it will not result in any significant delays to dredging/blasting or modifications of the dredge plan and any increased cost will be

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
		very small in comparison to the total costs of the project.
RPMs for Relocation Trawling		
18. You must report to us the number of sturgeon relocated and tagged as part of relocation trawling.	24. You must contact us weekly (not within 24 hours) to report on how many sturgeon were captured and to where they were relocated. A summary take report for sturgeon relocation trawling must be provided to us at the conclusion of each blasting season (no later than June 1, 2018). We will provide contact information annually when alerted of the start of dredging activity. Until alerted otherwise, you should contact Peter Johnsen: by email (Peter.B.Johnsen@noaa.gov) or phone (978) 282-8416 or the Endangered Species Coordinator by phone (978) 282-8480 or fax (978) 281-9394). Take information should also be reported by e-mail to: incidental.take@noaa.gov.	These RPMs and TCs are necessary and appropriate to ensure the 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. These RPMs and TCs 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.
19. You must ensure that the trawling is carried out in a way that minimizes the potential for injury or mortality of shortnose and Atlantic sturgeon.	25. Location (GPS), temperature, dissolved oxygen (D.O.), capture gear used (e.g., mesh size, trawl), soak time, species captured, and mortalities must be measured and recorded (at the depth fished) each time nets are set. This data must be included in the final	These RPMs and TCs are necessary and appropriate as they will serve to ensure that sturgeon captured in relocation trawling have a minimized risk of long term injury and mortality during

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	report submitted to us. 26. Gear must be deployed only in waters where D.O. levels > 4.5 mg/L at the deepest depth sampled by the gear for the entire duration of deployment. 27. Trawls may be towed at an average speed up to 3.0 knots for up to 15 minutes; however, when anticipating larger catches, towing time should be minimized to limit overdue stress on catches. 28. If a trawl (or other gear) becomes snagged on bottom substrate or debris, it must be untangled immediately to reduce potential stress on captured animals. 29. To accommodate larger catches, if applicable, those carrying out relocation trawling must carry secondary net pen(s) in the research vessel; overcrowded fish must be transferred to the spare net pens or else released. Given that sturgeon can suffer from frostbite when held in pens, when air temperatures are below freezing, the net pen must be periodically monitored.	tagging and relocation. This represents only a minor change as following these procedures should not increase the cost of the dredging operation or result in any delays of reduction of efficiency of the dredging project.

Reasonable and Prudent Measures (RPMs)	**Terms and Conditions (TCs)**	**Justifications for RPMs & TCs**
20. All tagging and associated surgery must be carried out in a way that minimizes the potential for long term injury and mortality of shortnose and Atlantic sturgeon.	30. When fish are onboard the research vessel for processing, the flow-through holding tank must allow for total replacement of water volume every 15 minutes. Backup oxygenation of holding tanks with compressed oxygen is necessary to ensure sturgeon do not become stressed and D.O. levels remain at or above 4.5 mg/L. 31. Any sturgeon overly stressed from capture must be resuscitated and allowed to recover inside net pens or live well; prior to release, it may only be PIT and Floy tagged, weighed, measured and photographed. 32. Holding tanks must be cleaned and thoroughly rinsed after use. 33. Onboard handling of sturgeon should be minimized, keeping fish in water as much as possible and supporting with a sling or net. 34. Prior to release, sturgeon should be examined and, if necessary, recovered by holding fish upright and immersed in river water, gently moving the fish front to back, aiding freshwater passage over the gills to stimulate it. The fish should be released only when showing signs of vigor and able to	These RPMs and TCs are necessary and appropriate as they will serve to ensure that sturgeon captured in relocation trawling have a minimized risk of long term injury and mortality during tagging and relocation. This represents only a minor change as following these procedures should not increase the cost of the dredging operation or result in any delays of reduction of efficiency of the dredging project.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	swim away under its own power. A spotter should watch the fish, making sure it stays submerged and does not need additional recovery. 35. When inserting numbered Floy tags, tags must be anchored in the dorsal fin musculature base by inserting forward and slightly downward from the left side to the right through the dorsal pterygiophores. 36. Surgical implantation of internal tags must only be attempted when fish are in excellent condition. During surgical procedures, instruments must be sterilized or changed between uses. To ensure proper closure of surgical incisions, a single interrupted suturing technique should be applied. 37. Anyone performing anesthesia on sturgeon must have first received supervised training on shortnose or Atlantic sturgeon or another surrogate species before doing so. Only non-stressed animals in excellent health should be anesthetized. To avoid injury while anesthetizing sturgeon in bath treatments, researchers must use restraint (e.g., netting) to prevent animals from	

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	jumping or falling out of the container. When inducing anesthesia on sturgeon, researchers must observe fish closely to establish the proper level of narcosis. While performing a surgical procedure, if sudden reflex reaction from an anesthetized fish is encountered, the Researcher must stop the procedure and evaluate the level of anesthesia before proceeding. Researchers must observe sturgeon closely during recovery from anesthesia, ensuring full recovery prior to release.	

12.0 CONSERVATION RECOMMENDATIONS

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

(1) To the extent practicable, you should avoid dredging during times of year when listed species are likely to be present. Specifically, all dredging above the salt front (i.e., Reaches B, A, AA, A-B, B-C, C-D) should be avoided when possible from April 1 – September 30.

(2) You should continue to support studies of Atlantic and shortnose sturgeon spawning locations in the Delaware River, behavior and spatial occurrence of early life stages, life stage duration, and other information that may allow refinement of dredging. This is to explore the possibility of developing measures to avoid and minimize effects to spawning, eggs, yolk-sac larvae, and post yolk-sac larvae.

(3) Population information on certain life stages of shortnose sturgeon is still sparse for this river system. You should continue to support studies to evaluate habitat and the use of the river, in general, by juveniles as well as use of the area below Philadelphia by all life stages. Population estimates are also lacking for Atlantic sturgeon. You should continue to support studies to assist in gathering the necessary information to develop a population estimate for the NYB DPS (as well as other Atlantic sturgeon DPSs).

(4) You should conduct studies at the upland dredged material disposal areas to assess the potential for improved screening to: (1) establish the type and size of biological material that may be entrained in the cutterhead dredge, and (2) verify that monitoring the disposal site without screening is providing an accurate assessment of entrained material.

(5) If a hopper dredge is used outside of Reaches D and E, you should consider using a dredge equipped with the rigid deflector draghead as designed by your 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) You should support studies to determine the effectiveness of using a sea turtle deflector to minimize the potential entrainment of sturgeon during hopper dredging.

(7) You should support efforts to report and keep track of sturgeon carcass in the Delaware River. These reporting efforts provide important information to evaluate causes of sturgeon mortalities within the Delaware River basin and along the New Jersey coast. Support could include the development, in cooperation with state agencies, of a central reporting database that standardize across states the procedures for reporting and keeping track of observations of sturgeon carcasses.

(8) You should use your authorities to support an ongoing sturgeon carcass tracking study by the Delaware State University. This would address the question of drift following mortality.

13.0 REINITIATION OF CONSULTATION

This concludes formal consultation on your proposal for deepening the Delaware River Philadelphia to the Sea Federal Navigation Project (FNP), as well as 50 years (through 2068) of maintenance dredging of the Federal navigation channel from Trenton, New Jersey to the Sea (to previously authorized depths), associated beach nourishment projects, and the installation of the Marcus Hook range lights. 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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