ENDANGERED SPECIES ACT SECTION 7 CONSULTATION

BIOLOGICAL OPINION

Agency: **U.S. Army Corps of Engineers, Philadelphia District**

Activity: **CENAP-OP-R- 2016-0181-39 DRP Gibbstown Shipping Terminal and Logistic Center**

NER-2017-14371

GARFO-2017-00176

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Conducted by: NOAA's National Marine Fisheries Service

Greater Atlantic Regional Fisheries Office

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Approved by:

Contents

1 INTRODUCTION

This constitutes NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Opinion) issued in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of the Delaware River Partners Gibbstown terminal and logistic center development. The U.S. Army Corps of Engineers (USACE) is the lead federal agency and is proposing to issue a permit authorizing components of the construction under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act to the Delaware River Partners, LLC. (DRP or Applicant).

We (NMFS) are basing this Opinion on information provided in a Biological Assessment (BA) dated August 11, 2017, the revised April 2017 Alternatives Analysis, the revised May 2017 Dredge Material Management Plan, other materials provided by the Applicant, and other sources of available information as cited in this Opinion. We will keep a complete administrative record of this consultation on file at our Greater Atlantic Regional Fisheries Office (GARFO), Gloucester, Massachusetts.

2 BACKGROUND AND CONSULTATION HISTORY

The proposed marine terminal involves redeveloping two former berths into a single berth and multi-use, deep-water port and logistics center (also referred to as "proposed project"). The development will occur on a 218-acre portion of a 1630-acre tract formerly known as the Dupont Repauno Works at 200 N. Repauno Avenue in Gibbstown, Gloucester County, New Jersey ("project site"). The Project is located at river mile 86.5 (RM; references are based on DRBC, 1969) or river kilometer (RKM) 139.2 and at Latitude N 39.84449/Longitude W 75.30074 (See Figure 3-1).

We began coordination with USACE, the Applicant, and the Applicant's project team in October 2016 regarding the potential development of the proposed marine terminal. We conducted pre-consultation coordination with the USACE and the Applicant during a series of meetings and phone conversations.

> On October 14, 2016, we participated in a conference call with the USACE, Applicant, U.S. Fish and Wildlife Service (USFWS), GARFO Habitat Conservation Division (HCD), New Jersey Department of Environmental Protection (NJDEP), and other stakeholders to discuss the potential environmental impacts caused by this project. During the phone call, we provided information on presence of the ESA-listed species under our jurisdiction and the potential effects from developing the proposed marine terminal.
>
> On March 6, 2017, the USACE issued a public notice to solicit comments and recommendations concerning issuance of a Department of the Army permit for the work permitted.
>
> On March 7, 2017, the USACE sent an email requesting concurrence with their determination that the proposed permitting of the project under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act was not likely to adversely affect (NLAA) ESA-listed species under our jurisdiction.

On March 29, 2017, we had a conference call with USACE to discuss the project and their NLAA determination. Both agencies agreed that the scope and effects of the project would warrant formal consultation and that the USACE would withdraw their request for concurrence with their NLAA determination. We also agreed that the consultation would include an analysis of effects from operation of the terminal and its related vessel traffic.

We sent a letter dated March 29, 2017, requesting that the USACE extend the Public Notice comment period by 30 days per the Memorandum of Agreement between the Department of the Army and the Department of Commerce, dated August 11, 1992. The USACE agreed and the expiration date for the Public Notice was moved to May 5, 2017.

On March 30, 2017, we participated in a conference call with the USACE, USFWS, NJDEP, DRP, and their consultants to discuss the project and regulatory issues. USACE informed the call participants that they would withdraw their request for concurrence with their NLAA determination, they would request formal consultation, and they would develop a biological assessment (BA).

The USACE sent a letter dated April 4, 2017, withdrawing their NLAA determination.

In response to the March 6, 2017, public notice, we sent a letter to USACE dated May 5, 2017 providing comments on the proposed development and operations of the marine terminal. The letter included information on the action area, presence of ESA-listed species under our jurisdiction, effects on listed species from the proposed marine terminal, and measures to avoid or minimize effects to listed species.

On May 17, 2017, the Applicant submitted a modification of the proposed marine terminal to USACE, implementing additional minimization and avoidance measures to protect listed species and proposed critical habitat. The measures include shifting the wharf 50 feet channelward to reduce the dredging footprint and modifying the pile design, as well as changing the means of constructing the wharf so that the piles would be mostly driven by vibratory hammer.

On June 13, 2017, the Applicant submitted a letter to provide updated projections of expected vessel calls to the proposed marine terminal.

On June 26 and 27, 2017, we met with the USACE and the Applicant to further discuss the Project, and the development of the BA.

From April 7 through August 23, we provided the USACE with information on listed species for development of the BA and commented on multiple versions of the draft biological assessment.

On August 11, 2017, we received a letter from USACE dated August 10, 2017, requesting initiation of formal consultation with an enclosed final biological assessment.

We sent a letter to the USACE dated August 28, 2017, agreeing that we had received all information necessary to evaluate the effects of the proposed action and initiate consultation. The letter informed the USACE that the date of initiation was the day we received all necessary information on August 11, 2017, and that the statutory date for delivering a biological opinion was December 24, 2017.

3 DESCRIPTION OF THE PROPOSED ACTION

The Applicant proposes to develop a multi-use marine terminal on property that they own at 200 North Repauno Avenue in Gibbstown, Gloucester County, New Jersey (Figure 3-1). The site was previously known as the DuPont Repauno Works. As part of this development, the Applicant is proposing to rehabilitate a former two-berth marine terminal by constructing a single multi-use berth with a draft accessible to vessels using the Delaware River navigation channel. The activities that are subject to USACE authority under Section 404/Section 10 permitting include proposed demolition of the existing bulkhead installation of docking structures, performance of dredging, installation of six outfall structures and future maintenance dredging. Prior to conducting these activities, DRP would complete related construction activities landward of the high tide line, including the installation of a sheet pile wall. A general sequence of construction is provided in Section 3.1. Section 3.2 describes the planned demolition of existing structures. Dredging would also be required to construct the berth. The dredging activities and management of dredged material are described in Section 3.3. A detailed description of the structures associated with this berth are described in Section 3.4. Interdependent and interrelated activities are described in Section 3.7 and include the construction and operation of the upland portion of the marine terminal and logistic center as well as vessel traffic using the marine terminal.

In the biological assessment for this project, the USACE uses a 30-year lifetime for the proposed marine terminal in assessing the proposed marine terminal's effects on listed species under our jurisdiction (USACE 2017a). Considering that the operation of terminals depends on regional economics and demands as well as technical advances, we cannot provide a more accurate estimate of the lifetime of the project or conclude that effects of the terminal beyond 2047 are reasonably certain to occur. Thus, we use the 30-year life time of the terminal in accordance with the biological assessment. Effects of the proposed marine terminal are related to the transport and handling of cargo and, therefore, the active operation of the terminal for importing and exporting cargo. Thus, we consider effects from operation of the proposed marine terminal to extend from its development until 2047.

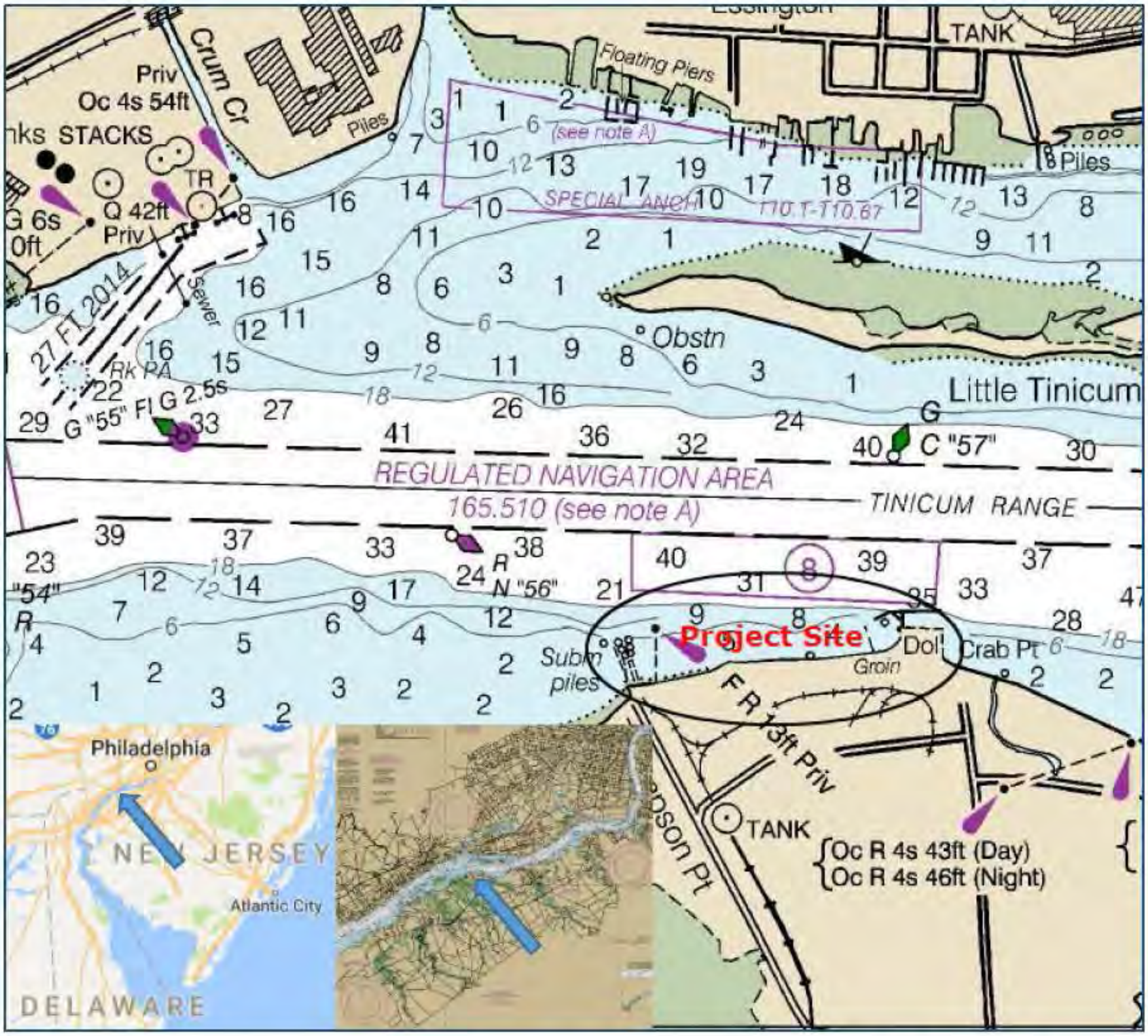

Figure 3-1. Map showing the location of the proposed Marine Terminal in the Delaware River.

3.1 General Sequence of Construction

The general sequence of construction of the proposed berth would be as follows:

- Demolish bulkhead (2 months)
- Conduct dredging (5 months and before April 1, 2018)
- Install berth piles (2.5 months and before April 1, 2018)
- Install berth deck (5 months)
- Install berth mechanical, piping, electrical systems, and install fenders
- miscellaneous deck equipment on deck (5 months)
- Complete dredging (if needed, 3 months)
- Construct stormwater outfalls (1 month)

This schedule assumes that construction would occur up to 12 hours per day, 6 days per week, and dredging activities would occur up to 24 hours per day for 7 days to minimize the overall duration of in-water work. Components of the proposed action are described further in the following sections.

3.2 Demolition Bulkhead

The existing bulkhead would be demolished with land-based equipment as follows:

- An excavator would remove fill material and pull out the timber structures of the bulkhead;
- A crane would use a vibration to pull out the 12-inch timber piles (approximately 40 to 45 ft. in length);
- A floating containment boom would be used during demolition activities to contain floating debris.

3.3 Dredging and Dredged Material Management

This section describes the dredging related activities that are necessary to construct the berth. These activities would include dredging the sediment, dewatering the dredge material, and the management of the dewatered dredged material, depending on the level of contamination detected in sediments. To construct the berth, a 27-acre area would be dredged to a depth of -40 feet mean lower low water ± 1 foot overdraft. Approximately 13 acres of the waterway was last dredged in 1992 in association with operations of the previous owner. In 1969, a small area (approximately 0.5 acres) adjacent to the wharf was dredged.

As presented in Table 3-1, a total of 371,000 cubic yards (cy) of dredged material would be dredged from the dredging area. Of this total, 118,000 cy are uncontaminated coarse-grained sediments (i.e., sand). The remaining 253,000 cy is fine-grained sediment (generally silt). As presented in the Dredged Material Management Plan (Ramboll Environ 2017, Appendix A) that was prepared by the Applicant and submitted to USACE, sampling within the dredging area indicates that the fine-grained sediments are contaminated with polycyclic aromatic hydrocarbons (PAHs), certain metals (primarily arsenic) and polychlorinated biphenyls (PCB) aroclors at concentrations exceeding New Jersey's Residential Direct Contact Soil Remediation Standards (NJRDSRS) and are hereafter referred to as “impacted.” NJDEP requires that once these impacted sediments, which total 72,000 cy, are dredged, they are disposed in accordance with NJDEP requirements.

Table 3-1. Volume of Dredged Material to be managed.

Category	Volume (cy)
A. Impacted fine-grained dredged material to be managed at an upland landfill or brownfield site	72,000
B. Non-Impacted[1] fine-grained dredged material to be transported to a Confined Disposal Facility (CDF)	181,000
C. Sandy dredged material to be transported to a CDF or reused on site	118,000
TOTAL	371,000

The location of impacted sediments is shown on Figure 3-2. Sediment that is not impacted will be taken to the Whites Basin Confined Disposal Facility (CDF) approximately four river kilometers downstream from the project site. The process for handling each of these categories of materials is described below.

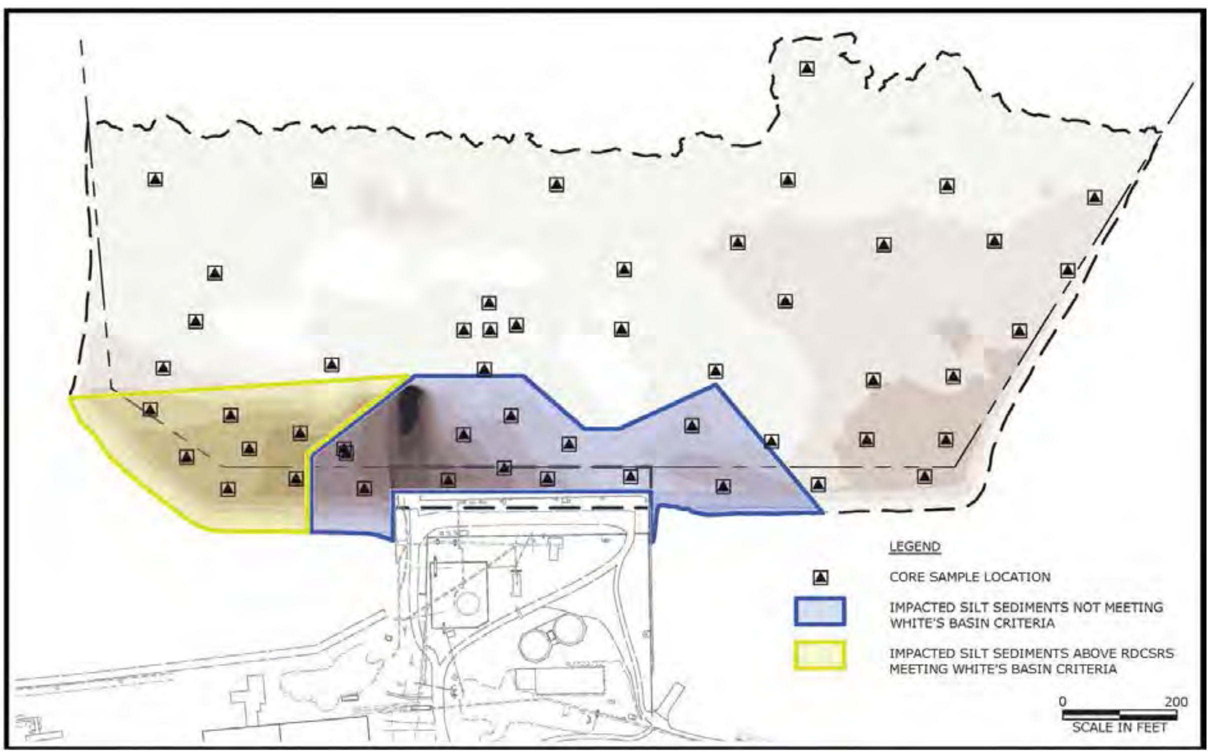

Figure 3-2. Affected silt areas that meet White's Basin criteria and silt areas that exceed White's Basin Criteria.

[1] For purposes of this Action, non-impacted dredged material is material that either has contaminants present at concentrations below NJRDCSRS or at concentrations exceeding NJRDCSRS, but not exceeding the acceptance criteria for one or more CDFs.

In the future, maintenance dredging is expected to occur approximately once every 10-15 years. The proposed berth is located at a strategic bend in the river that limits sedimentation and is parallel to the flow of the river; therefore, only limited silting along the berth face is expected. It is estimated that minor berth maintenance dredging (5,000-7,500 cy) would be required approximately every 10-15 years. It is expected that the material to be dredged is a fine-grained sediment; contaminant testing would be conducted as required by NJDEP and USACE. Given the volume of material to be dredged, this activity would require 2 to 3 days to be completed. Dredged material handling is described below. The maintenance dredging activity would not occur between March 15 and July 15, to comply with seasonal work restrictions for the Delaware River. Further, the Applicant has committed to only conducting hydraulic dredging between September 15 and April 1 of any year.

3.3.1 *Dredging Sequence*

Dredging will be conducted in the following sequence:

- A closed clamshell bucket will mechanically dredge all fine-grained sediments within the dredging area.
    - The impacted sediments that cannot be placed at a CDF due to contaminant concentrations (see Figure 3-2) would be dredged first.
    - Then, the non-impacted fine-grained sediments which can be accepted by a CDF would be dredged. At most locations, when the necessary dredging depth is reached, the underlying uncontaminated sand would be encountered and constitute as the new bottom surface;
- Prior to commencing dredging of the underlying sand material, a final pass of the dredging area would be performed using the closed clamshell environmental bucket.

Finally, the sandy sediment would be dredged using a hard-digging bucket dredge or hydraulic dredge and managed as described in Section 3.3.5.

3.3.2 *Dredging Methods*

A closed clamshell environmental bucket will mechanically dredge all fine-grained sediment. Implementation of Best Management Practices (BMPs) described in Section 3.8.2 will control turbidity. Dredged material will be placed in water tight barges (hopper barges). The barges will be transported to a dewatering station, where the material will be allowed to settle leaving free-standing water at the top of the barges (see Section 3.3.3).

Once the fine-grained sediment is removed from the dredging area, the underlying sand would be removed and managed as non-impacted dredged material. Depending on schedule and equipment availability, one of two options described below would be used to dredge and manage the sand:

> ***Option 1: Hydraulic Dredger***
>
> Using a hydraulic pipeline dredge, non-impacted sand would be dredged and conveyed directly to Whites Basin in Logan Township, New Jersey via submerged pipeline directly to Whites Basin. The 30-in diameter pipeline would be marked per U.S. Coast Guard regulations and would be located no nearer than 100 feet from the edge of the Federal navigation channel. Based on the dredge volume and the expected production rate of the

equipment, dredging of non-impacted sediment would be completed in approximately 10 to 12 days.

Option 2: Hard-digging Bucket Dredger

Using a hard-digging bucket dredge staged on a barge, sandy material would be placed in a hopper barge and allowed to decant and excess water would return to the waterway. The dewatered sand would then be transferred via barge to a CDF or the adjacent upland project site. Hard-digging dredge buckets are typically heavier and have a more powerful closing mechanism than soft-digging buckets (USACE 1975).

3.3.3 *Dewatering of Dredged Material*

Dewatering of dredged material (including all fine-grained and sandy material) in the hopper barges would be conducted with the objective of minimizing the addition of suspended solids, turbidity, or sheens to the receiving water body. Free water would not be discharged back to the river sooner than 24 hours, and only if the concentration of total suspended solids (TSS) is less than 30 mg/l as required by NJDEP. With impacted and non-impacted dredged material alike, TSS is typically used to assess water quality impacts, because organic contaminants tend to bind to sediment particles. Dewatering operations would be performed to avoid re-suspending or pumping previously settled sediment. As required by NJDEP, dewatering would be conducted as follows:

- The main method of decanting would be to pump the water (i.e., supernatant) from the loaded barges into water holding (decant) barges that allow for additional settling. Free water would be pumped into a decant barge for a settling period of 24 hours and then discharged back into the river.
- To reduce the holding time in the decant barge, TSS samples may be collected from water in the decant barge after 12 hours. If the concentration of TSS is less than 30 mg/l or measured background concentrations, based on three consecutive TSS analyses, then the hold time for decant water would be set at 12 hours.
- Water would be pumped from the decant barge through a discharge hose that would be submerged to minimize turbidity. Screens would be used on the dewatering hoses to minimize the passing of solids.

3.3.4 *Disposition of Fine-Grained Dredged Material at CDF*

Following dewatering as described above, clean fine-grained sediments would be transported by barge to a nearby CDF, if approved for acceptance. 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 to allow the discharge to meet specified conditions. 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. Proper weir design and operation can control potential resuspension and release of solids. 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.

Clean fine-grained dredged material that meets Whites Basin acceptance criteria would be transported by barge to Whites Basin where it would be pumped from the barge into the rehandling basin. If transported by barge, dredge material will be deposited in a semi-enclosed basin in the Delaware River (Whites Basin). Sediment in the rehandling basin is again dredged and placed in the adjacent upland CDF. The upland CDF at Whites Basin is a permitted CDF with a dredged material rehandling basin located along the southeast shore of the Delaware River between the mouths of Repaupo and Raccoon Creeks, on the north side of the Commodore Barry Bridge (U.S. Route 322), in Logan Township, Gloucester County, New Jersey (See Figure 3-3).

Provided that space is available, clean dredged material that meets the USACE's Ft. Mifflin acceptance criteria would be transported by barge to that facility where it would be hydraulically offloaded in the upland CDF. The Fort Mifflin CDF is located in Southeast Pennsylvania in Philadelphia County. This CDF is located at the confluence of the Schuylkill and Delaware Rivers on the former Hog Island (See Figure 3-3). This CDF and all of its operations are located entirely within Federally-owned property. The Fort Mifflin CDF is divided into three cells. Cells A, B and C are 85, 82 and 80 acres in size, respectively. Cells A and B discharge water to the Schuylkill River; Cell C discharges to the Delaware River. Each cell has a baffle dike to increase the residence time that water remains in the cells allowing suspended sediment to settle out of the water before discharge occurs. The surface of the three cells are covered with dense vegetation, primarily weeds, phragmites, and brush. Vegetation slows water movement, which also facilitates settling of suspended sediment

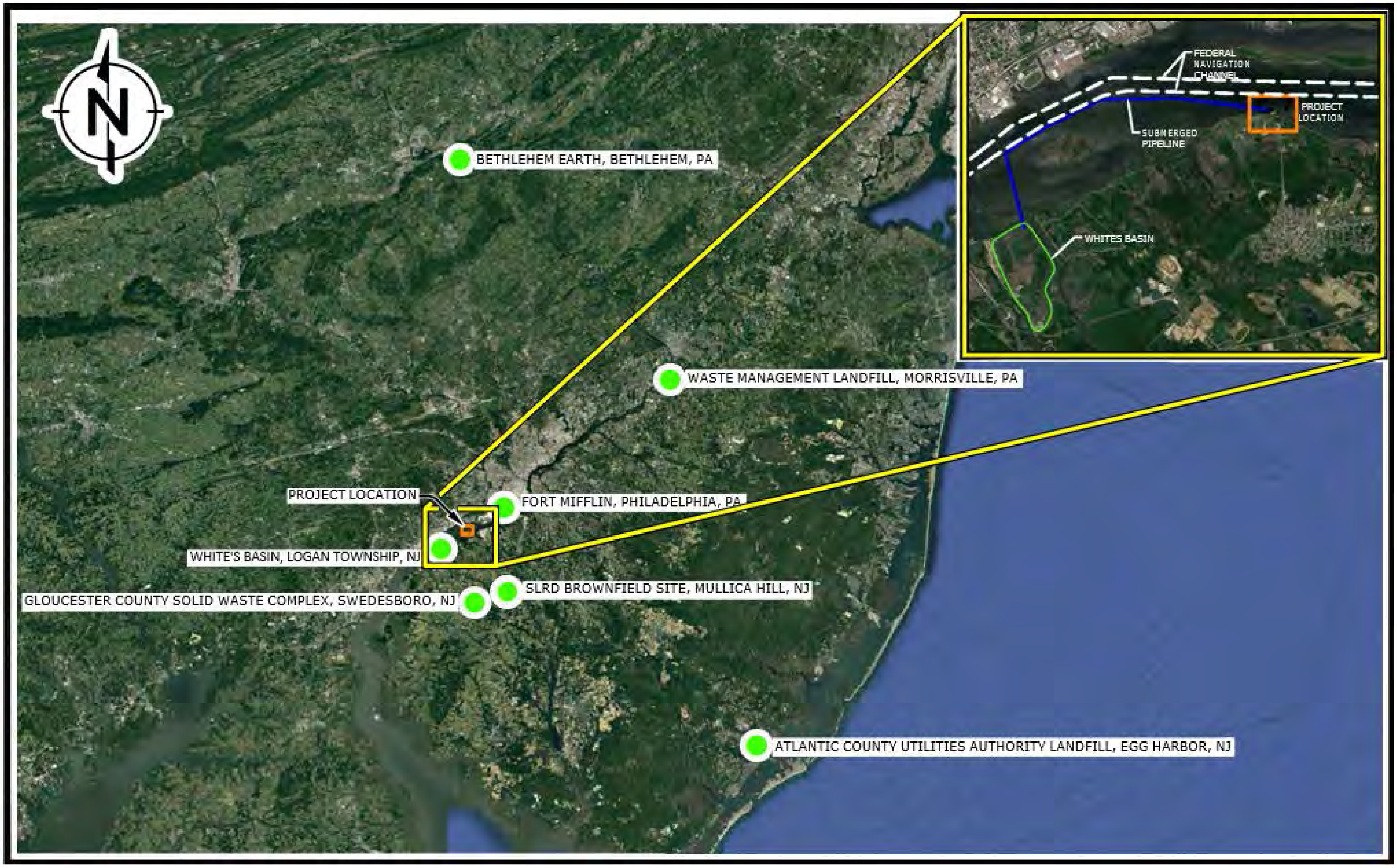

Figure 3-3. Location of hydraulic pipeline and disposal locations for dredged sediments.

3.3.5 *Management of Sandy Material*

After the fine-grained sediments are dredged, sands would be dredged as described above. If the sand is hydraulically dredged, it would be conveyed directly to Whites Basin in Logan Township, New Jersey by submerged pipeline directly to Whites Basin and no dewatering of the sediments would be necessary. As stated above, the pipeline would be marked per U.S. Coast Guard regulations and would be located no nearer than 100 feet from the edge of the Federal navigation channel. If the sand is dredged by hard-digging bucket, it would be managed in one of two ways, following placement in a barge and dewatering as described in Section 2.3.3:

Option 1 – Beneficial Reuse on Site

If the dredged sand can be beneficially used at the Project Site, the dewatered sand would be offloaded from the barge to the stockpile area on the adjacent Project Site. Trucks would move it from the stockpile to the designated fill areas on the Project Site.

Option 2 – Disposal at Permitted CDF

If the dredged sand is disposed at Whites Basin CDF, it would be transported by barge to that facility, where it would be bottom-dumped into the rehandling basin. Whites Basin is located at RKM 132 (RM 82), so sand-filled barges would travel four river miles from the Project Site downriver to Whites Basin.

If the dredged sand is disposed at Ft. Mifflin CDF, it would be transported by barge to that facility, where it would be hydraulically offloaded. Ft. Mifflin is located at RKM 147.3 (RM 91.5), so barges would travel 5.5 river miles from the Project Site upriver to Ft. Mifflin CDF.

3.3.6 *Management of Dredged Material for Upland Disposal*

Impacted dredged material (i.e., fine-grained sediments that do not meet the CDF acceptance criteria) would be dredged with a closed-clamshell bucket (see Section 3.3.2), dewatered (see Section 3.3.3), and amended (as described in this subsection) to enable DOT-compliant transportation by truck and to meet receiving landfill or brownfield site acceptance criteria. Figure 3-4depicts the layout of the dredging and processing activities. Figure 3-5 shows the equipment and process flow needed to carry out the dredging and processing of the dredged material.

The dredged material would be mixed and amended using an in-barge processing facility located adjacent to the Project Site or at a waterside location in Camden, New Jersey (see Figure 3-3), owned by Weeks Marine. The Camden waterside location has a Waterfront Development Permit and the USACE authorization (CENAP-OP-R-2013-0696-46) to operate an in-scow processing facility. Weeks Marine is located at RM 100.5, so barges would travel 14.5 river miles from the Project Site upriver to Weeks Marine. The following process would occur at either the Project Site (as shown in Figure 3-5) or the Weeks Marine facility:

- Hopper barges containing the decanted dredged material would be brought alongside a processing barge for treatment.
- Prior to the start of treatment, an excavator would remove any visible debris on top of the dredged material. Debris would be placed onto the deck of the processing barge for later disposal at a licensed landfill.

- The dewatered impacted sediments would be mixed with Portland cement in the dredge processing barge (In-Barge Amendment or In-Barge Processing). Portland cement is a pozzolan that reacts with the sediment slurry to bind sediment particles together and effectively reduce its water content, improving the material's handling and compaction characteristics, as well as reducing the leaching potential of bound contaminants (Maher *et al* 2013).
- The excavator stationed on the processing barge would lower its mixing head into the scow starting in one corner and mix one section at a time as the slurry is being pumped. The hopper barge would be fleeted alongside the processing barge by a deckhand during the treatment process. Once processed, the material would be allowed to cure (up to 24 hours depending on moisture content of the material).

An example of a barged-based, in-scow processing facility arrangement is shown in Figure 3-4 and in Figure 2-6 in the biological assessment for this project.

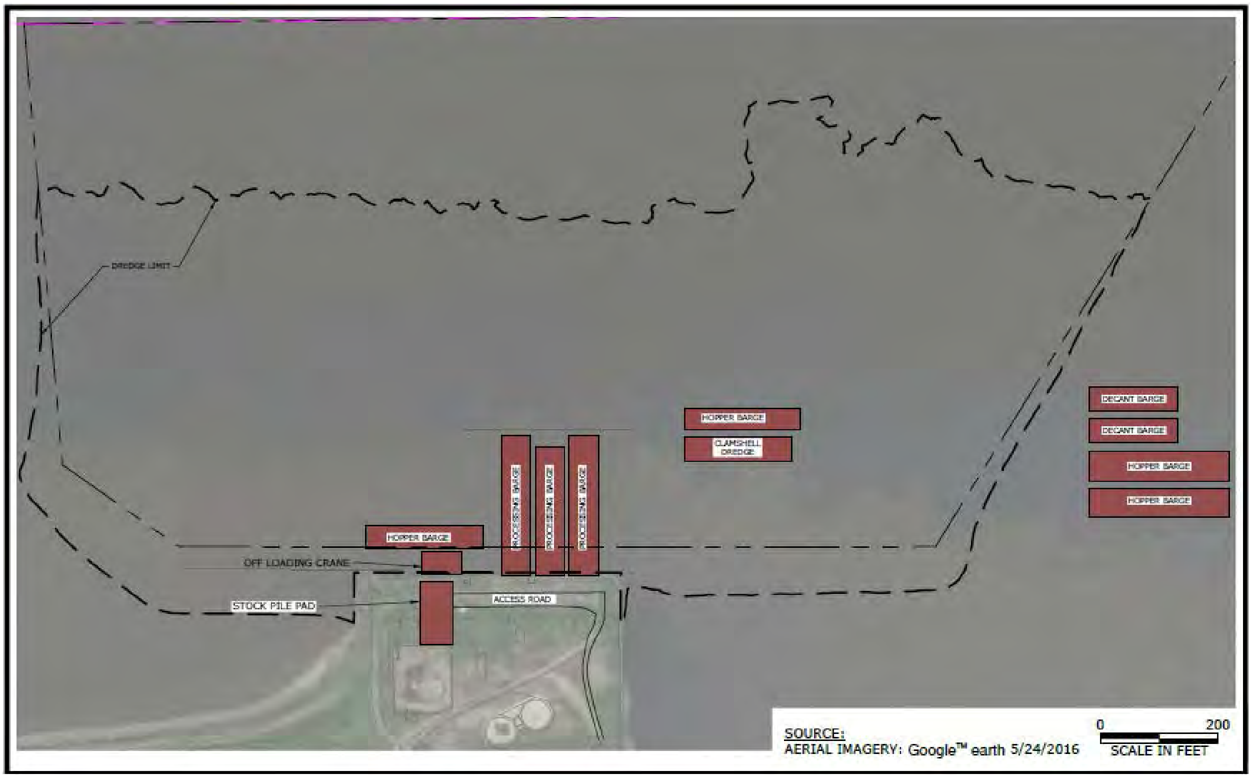

Figure 3-4. Dredging and processing layout.

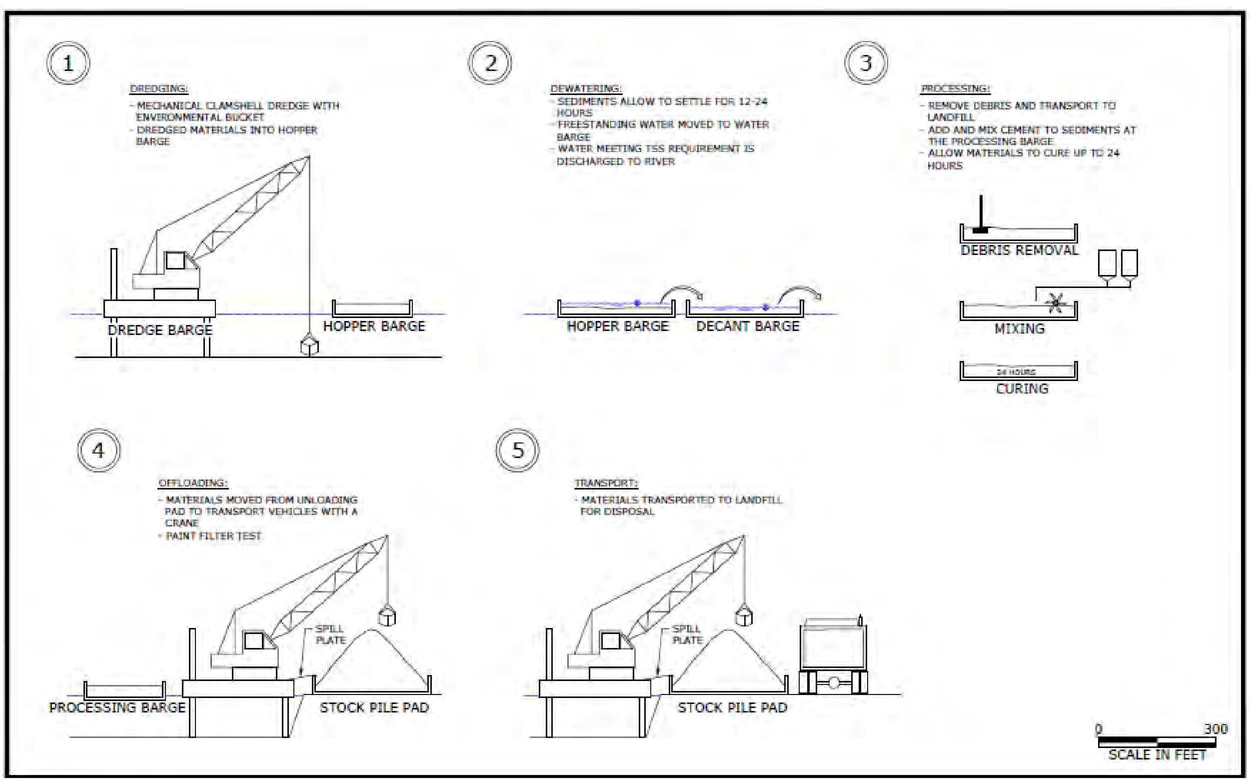

Figure 3-5. Schematic presentation of proposed dredging operation sequence.

After the in-scow stabilization period, amended dredged materials would be off-loaded and stockpiled on the adjacent land on a low-permeability pad. This pad would be designed with runoff and erosion control systems. As required under Soil Erosion and Sediment Control (SESC) requirements, the plans for this storage pad will be submitted to and approved by New Jersey state and local government entities as required.

Once the amended dredged materials are solidified and pass the paint filter test,[2] and any additional required testing is completed, the amended dredged materials would be loaded into dump trucks with sealed tailgates for transport to an approved landfill or brownfield site.

The amended dredged material would be loaded into dump trucks using a front-end loader with a 6 CY bucket. A scale system would be installed in order to accurately weigh the amended dredged materials loaded into the truck.

The dump trucks would be licensed to haul solid waste by NJDEP. Gasketed and/or turnbuckle tailgates would be used to ensure that no water or mud is lost from the truck during transport.

The amended dredged material would be transported to one or more approved landfills or brownfield sites (See Figure 3-3), depending on schedule, volume, final testing and approval.

3.4 Construction of Berth Structure

The berth structure would be pile-supported; extending waterward from an existing 450-foot long earthen berm/wharf, extending upriver approximately 97 feet and down river 200 feet, with a total length of 750 feet.

Prior to construction of the berth structures, related construction landward of mean high water would occur. This will include installing a steel sheet pile wall landward of the existing bulkhead that remains from the previous owner. As part of this action, the bulkhead would be demolished, such that 21,854 square feet (SF) open water would be restored (excluding fill associated with the new pile-supported structure). The new berth would include a continuous open deck platform connected to the earthen berm, as further detailed below.

- Connected parallel to the earthen berm, a 454-foot long, 93-foot wide open deck platform would be constructed on 156 30-inch steel piles.
- The concrete open deck platform would extend 200 feet downriver of the berm and would be 140-foot wide, supported by 112 30-inch steel piles.
- The concrete open deck platform would extend approximately 97 feet upriver of the earthen berm and would be 140-foot wide, and supported on 28 30-inch steel piles and 43 36-inch steel piles.
- A 44-foot by 15-foot breasting dolphin would be attached to the upstream concrete pier by a 94.6-foot long steel walkway. The dolphin would be supported on 15 24-inch steel pipe piles.

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[2] The Paint Filter Liquids Test (EPA Method 9095B) is used to determine the presence of free liquids in a representative sample of waste. A predetermined amount of material is placed in a paint filter. If any portion of the material passes through and drops from the filter within the 5-min test period, the material is deemed to contain free liquids. The method is used to determine compliance with 40 CFR 264.314 and 265.314.

- Also attached to the upriver pier, landward of the breasting dolphin, a steel walkway would extend 164 feet to a 17 feet square mooring dolphin. The dolphin would be supported on 12 24-inch pipe piles. The steel walkway would be supported by a concrete support structure and 2 24-inch steel piles;
- From this dolphin, a 162.5-foot long steel walkway would extend to a second 17 foot square mooring dolphins. The dolphin would be supported on 12 24-inch pipe piles. The steel walkway is supported by a concrete support and 2 24-inch steel piles.

Table 2-2 in the biological assessment only included piles that will be located within USACE's jurisdiction (below the high tide line). Table 3-2 below has been revised from the biological assessment to reflect the total number of piles specified above, and to include pilings placed both landward and waterward of the high tide line.

Table 3-2. Summary of Pile Sizes and Types used for Construction.

General Location	Pile Type	Number	Diameter	Distance between piles
Wharf	Steel pipe	296	30-in	3 – 18 feet
Wharf	Steel pipe	43	36-in	9 feet
Dolphins	Steel pipe	43	24-in	2 – 8 feet
Total Number of Piles	N/A	**382**	N/A	N/A

Driving the piles requires temporary placement of a template to establish the locations for the piles. A template is required to maintain piles in the proper position prior to driving and is removed and reused during the pile installation process. This template would be placed with a barge-mounted crane, and it will set the locations for 16-20 piles. Using a barge-mounted crane, each pile would set in place, and the weight of the pile would settle it into the softer sediments closer to the surface. Barge-mounted equipment would be used to drive each pile into place. First, a vibratory hammer would drive all piles positioned in the template to approximately -70 feet; piles would then be driven using an impact hammer with a wood cushion block to the final depth of -90 to -100 feet. It is estimated that 10-12 piles could be driven in one day. The template would then be repositioned and the sequence repeated. Following completion of pile driving activities, the template would be removed from the work area. A bubble curtain and a “soft start” procedure would be used to reduce the effect of noise. Additional mitigation measures to minimize effects of pile driving are described in Section 3.8.1. The concrete piers would be cast in place or be pre-cast materials and installed using land-based equipment.

3.5 Construction of Stormwater Outfalls

Three headwall structures and associated rip-rap aprons would be constructed with a combined footprint of approximately 3180 SF waterward of the high tide line of the Delaware River (See Figure 2-7 in the biological assessment for this project). A fourth headwall structure would be constructed in a ditch on C-Line Road, located landward of the high tide line on the upland marine terminal. Each structure would be built with a concrete headwall with footings that extend at least three feet below grade. The structures would include scour holes and/or rip-rap aprons designed in accordance to the New Jersey Standards for Soil Erosion and Sediment Control, Chapter 22. All outfall structures would be positioned to maintain normal flow of the channels.

Before beginning upland construction, a NJDEP construction stormwater general permit would be obtained and a Soil Erosion and Sediment Control (SESC) plan would be prepared and submitted for approval. The SESC plan would include standard controls, such as temporary stabilization, sediment traps and sediment barriers (i.e. turbidity curtain). Equipment used to construct the outfalls would be land based.

3.6 Vessel Traffic Related to Construction and Dredging

As presented in Section 3.1, the construction and dredging work would be sequential so vessels associated with dredging would not operate at the same time as vessels associated with construction.

On October 6, 2017, the USACE provided us with updated information on the estimated number of vessels that will be used during construction. Based on this updated information, as summarized in Table 3-3, the proposed construction of the berth structure will require six project-related vessels in the Delaware River. Of these, four vessels (tugboats, crew boat, and delivery boat) would have propellers. The two remaining vessels would be work barges that are maneuvered using project tugboats. The powered vessels have drafts ranging from three to six feet. During pile installation and construction of the berth structure, the barge-mounted equipment would be stationed in the immediate vicinity of the berth. Piles would be transported to the site on barges. Based on the number of piles required, approximately 10 barge trips would travel to the construction area from the Weeks Marine facility in Camden, New Jersey, located approximately 14.5 miles from construction area. The drafts of the barges would range from 1.8 to 2.4 meter (6 to 8 feet). Concrete required for constructing the deck would be transported to the waterfront from the landside.

The project vessels used for construction would operate 6 days per week, up to 12 hours per day between July 15 and March 15. When moving within the construction area, these vessels would generally operate at speeds of 4 to 5 knots.

As summarized in Table 3-4, the proposed dredging operations will require two tug boats, six hopper/decant barges, one work barge, and one crew boat. Decant barges would remain in the dredging area. It is estimated that approximately 300 hopper barge trips, with no more than eight barge trips per day, would be required to transport dredged material from the Project Site to a CDF or nearby site (in the case of impacted sediments). More than one barge may be moving at one time depending on time needed for dewatering and limitations imposed by the receiving facility. Transport of dredged materials may occur up to seven days per week during dredging operations. Use of Whites Basin would require barges to travel four river miles. Use of the Ft. Mifflin CDF would require barges to travel 5.5 river miles.

Table 3-3. Summary of the types and numbers of vessels used during construction.

Vessel Type	Number	Size (ft)	Draft (m/ft)	Operating Speed (knots)	Max Speed (knots)
Tugboats	2	85x24x11	1.2-1.8/4-6	3-5	10
Work barge	2	200x56x14	1.2-1.8/4-6	3-5	5
Crew boat	1	60x16x7.5	0.9-1.5/3-5	3-5	12
Delivery boat	1	52x14x7.5	0.9-1.5/3-5	3-5	10

Table 3-4. Summary of the types and numbers of vessels used during dredging.

Type	Number	Size (ft.)	Draft (m/ft.)	Operating Speed (knots)	Max Speed (knots)
Tugboats	2	85x24x11	1.2 – 1.8/4 – 6	3-5	10
Hopper/Decant Barges	6	230x40x12.5	1.2 – 2.7/4 – 9	3-5	5
Work Barge	1	225x54x14	1.2 – 1.8/4 – 6	3-5	5
Crew boat	1	60x16x7.5	0.9 – 1.5/3 – 5	3-5	12

The number of vessel trips related to the transport of dredged material is summarized in Table 3-5. It is assumed that each barge (unpowered) would require one tugboat to transit the river.

Table 3-5. Summary of the number of vessel trips needed for transport of different sediment types.

Destination	Sediment Type	Number of Vessel Trips (Barges and Tugs)
Whites Basin CDF or Ft. Mifflin CDF	Fine-grained dredged material	145
Ft. Mifflin CDF	Sandy dredged material	94
Weeks Marine Processing Facility	Fine-grained dredged material	58
TOTAL	**ALL**	**297**

3.7 Interdependent and Interrelated Activities

Interrelated activities are defined as actions that are part of the proposed project and depend on the proposed project for their justification. An interdependent activity is defined as an activity that has no independent utility apart from the action. Construction of the marine terminal facilities is interdependent with and interrelated to the proposed action described above. The proposed landside marine terminal facilities are located above the head of tide and are not regulated by the USACE per NJDEP's assumption of the Section 404 Program. The marine terminal would include facilities for automobile import/export and processing, and handling of general freight, break bulk cargo, and bulk liquid storage. No manufacturing would occur at the marine terminal. The footprint of the proposed marine terminal generally corresponds to previously disturbed, former industrial and manufacturing areas in 200 acres of the waterfront portion of the property. Except at the existing wharf, a riprap-protected levee extends along the shoreline of the property.

The proposed layout for the marine terminal configures the available property to allow for the following three cargo handling areas:

- Roll-on/Roll-off (RoRo) and General Cargo;
- Energy product storage for liquid gases, including propane and butane, refined petroleum products, and crude products; and,
- Logistics area (located more than 2,000 feet from the waterfront).

The marine terminal would be configured to provide for transport of cargo via rail, road, and/or ship and would provide appropriate support facilities. The RoRo (i.e., automobiles), general cargo, and bulk liquid areas would be contiguous and adjacent to the berth. This configuration would accommodate transit, intermediate covered storage, and internal circulation necessary for efficient operations. Delivery of waterborne cargo depends on waterfront transit warehousing, where cargo would be staged prior to processing at longer-term, value-added, and logistics facilities situated in the southern area of the project site. Because these logistics facilities are located more than 2,000 feet from the waterfront, they will have a separate stormwater management system not connected to the Delaware River. No other possible routes of effects to the Delaware River are known. As a result, activities associated with these facilities are not expected to affect NMFS listed species or critical habitat.

For the RoRo-General Cargo operation, stern ramps from car carriers and other RoRo vessels are expected to set down at a dedicated area on the 200-ft. x 140-ft. open wharf portions of the structure. Depending on vessel geometry, side ramps may deploy on the centrally located portion of the bulkhead. Vehicular turning movements were assessed using AutoTURN, a vehicle swept path analysis program. The largest anticipated vehicle was used for evaluating turning movements to and from the deployed stern ramp. Based on this evaluation, and the need to limit the potential for wide swings through the first point of rest, a 45-ft. x 45-ft. fillet was incorporated into the wharf structure as it transitions toward the land area.

For the Energy Product Storage operation, liquid bulk is expected to be accommodated at a dedicated loading area on the wharf. Safety and spill control measures would include containment and an Emergency Shut Down (ESD) system. In accordance with U.S. Environmental Protection Agency (USEPA) and U.S. Coast Guard (USCG) requirements, a containment boom would be used to contain leaks or spills of petroleum or other products from the vessels while moored at the wharf. It would consist of a semi-permanent containment boom would be positioned immediately landward of the outboard row of piles and a reeled containment boom attached to the wharf that would be deployed to encircle tanker vessels after mooring. The booms would be secured via boom slot, to accommodate variations in river level due to tidal fluctuations. Any presence of petroleum products or other contaminants on the surface and contained within the boom will be skimmed off before the boom is removed to allowing the vessel to departure.

3.7.1 *Construction of Marine Terminal*

Construction activities would include stabilization of the earthen berm by installing a steel sheet pile wall landward of the high water line and the existing timber cut-off wall that remains from the previous owner. This 1,065 linear feet (lf) sheet pile would be installed with land-based equipment and would serve as the earth retention structure for the new wharf structure. Construction of the landside marine terminal would start with clearing of vegetation, followed by placement of fill to raise the marine terminal to an elevation above the 100-year flood elevation, installation of stormwater management structures and other underground utilities, final grading and construction of storage areas and buildings.

Prior to the start of upland construction, a NJDEP construction stormwater general permit would be obtained and a SESC plan would be prepared and submitted for approval. The SESC plan would include standard controls, including but not limited to temporary stabilization, sediment traps, sediment barriers (i.e. perimeter fencing), inlet protection, and construction site waste control. A Stormwater Pollution Prevention Plan (SPPP) and Spill Prevention Plan (SPP) would also be developed for the Site as required. A State Section 401 Water Quality Certification was also issued on April 10, 2017 in conjunction with a Waterfront Development permit for the project. State water quality regulations have been designed to protect against degradation of water quality as a result of construction and or operations. State and Federal permitting requirements will govern impacts of landside construction activities on water quality in the Delaware River.

3.7.2 *Operation of Marine Terminal*

Stormwater management systems have been designed to meet applicable requirements of the New Jersey Stormwater Management Rules at N.J.A.C. 7:8.

On the berth structure and upland facility, stormwater runoff would drain via sheet flow and two trench drains. The stormwater would leave the trench drains and enter a closed storm drain system. The closed storm drain system would convey the stormwater to an oil/water separator. Oil and solids collected in that device would be periodically removed and properly disposed off-site. Separated water would be conveyed to the landside stormwater management system described below.

For the upland portion of the marine terminal, stormwater management has been designed so that pre-existing flow rates from the 2-year and 10-year storm events would not increase in post-development conditions. The development must treat runoff volume generated by the NJDEP-designated 1.25-inch, 2-hour water quality storm using stormwater management methods that reduce the developed site’s average annual TSS load for all watersheds, as required by the New Jersey Stormwater Management Rules at N.J.A.C. 7:8-5.5.

The stormwater management system is designed so that proposed development would meet 50% TSS removal for all redeveloped impervious coverage and 80% TSS removal for all new impervious cover as required by the New Jersey Stormwater Management Rules (N.J.A.C. 7:8).

The proposed improvements include two underground box culvert detention systems. The larger underground system, centered in the northern portion of the development, includes 3,000 lf of 12-ft x 5-ft box culvert. The system is designed to improve the water quality of the modeled storms prior to discharging to several manufactured treatment devices. The 12-ft x 5-ft box culvert would convey stormwater out of the underground system and into the Delaware River through 4 48-inch RCP outfall pipes. The smaller underground system would be centrally located on the southern portion of the development and would consist of 600 lf of 12-ft x 5-ft box culvert. The system would attenuate the 2-year and 10-year storm events to ensure flows to the existing channel are not increased above baseline conditions. A plan depicting the size and location of proposed stormwater facilities is included as Appendix C in the biological assessment for this project.

Additionally, two wet ponds are proposed to provide stormwater detention and stormwater quality. Wet Pond 2B, located in the southwestern corner of the property would attenuate all storm events event prior to discharging landward toward an existing swale.

3.7.3 *Environmental, Health, and Safety Programs for the Marine Terminal*

Operation of the marine terminal will be subject to several regulatory programs that require development of plans and implementation of measures for spill and leak prevention and spill containment in the event of release and safe operation of the facilities. These plans must be approved by USEPA or NJDEP and include:

- USEPA Oil Spill Prevention and Preparedness Program, which reviews and approves:
  - Spill Prevention Control and Countermeasures (SPCC) Plan
  - Facility Response Plan (FRP)

The SPCC plan includes guidelines for the following: requirements for the design of the marine terminal drainage to prevent uncontrolled discharges of oil beyond the limits of the marine terminal; requirements for the construction and installation of bulk storage tanks, including provision of secondary containment; and regular monitoring and inspection of storage containers, aboveground valves, piping, and appurtenances to ensure proper operation and no evidence of leakage or degradation of storage integrity. 40 CFR §112.7-112.8 provides a full list of SPCC plan requirements.

The FRP program is designed to ensure that facilities have adequate oil spill response capabilities. The program requires certain facilities to submit plans to respond to a worst case discharge of oil and to a substantial threat of such a discharge. The plan also includes responding to small and medium discharges, as appropriate. The following are key elements of a FRP:

- Emergency response action plan, including the identity of a qualified individual with the authority to implement removal actions;
- Emergency notification, equipment, personnel, evidence that equipment and personnel are available, and evacuation information;
- Identification of small, medium, and worst case discharge scenarios and response actions;
- Identification and evaluation of potential discharge hazards and previous discharges;
- Description of discharge detection procedures and equipment;
- Detailed implementation plans for containment and disposal;
- Facility and response self-inspection, training, exercises and drills, and meeting logs;

- Security measures, including fences, lighting alarms, guards, emergency cutoff valves, and locks.

- NJDEP Discharge Prevention Program, which reviews and approves
  - Discharge Prevention Containment and Countermeasure Plan (DPCC)

    The purpose of the DPCC plan is to prevent discharges from occurring, and if they do occur, to minimize the effects on the environment. Items that must be included in the DPCC plan are general information about the facility, a general site plan, a drainage and land use map and a topographical map, as well as information on storage areas, aboveground storage tank inspections, loading/unloading areas, process areas, in-facility piping, secondary containment/diversion systems, marine transfer areas, flood hazard areas, visual inspection and monitoring procedures, housekeeping and maintenance, personnel training, physical security measures, standard operating procedures, and recordkeeping. A list of discharges that occurred at the facility within the previous 36 months must also be included in the plan. A schedule to upgrade the facility to meet regulatory requirements may be included in the DPCC plan if necessary.

- NJDEP Toxic Catastrophe Prevention Act (TCPA) Program, a state-run program that is more stringent than Federal law. Under TCPA, the following plans will be submitted by DRP for covered processes:
  - Process Hazard Analysis: identifies and assess potential hazards that could be associated with operations involving the storage or transfer of certain hazardous substances.
  - Inherently Safer Technology Report: examines the design alternatives considered and employed by DRP to minimize or eliminate the potential for a release.
  - Safety Review of Design: provides the details on the safety features involved in the design, construction, and operation of covered processes.
  - Risk Management Plan: defines and documents the potential risks associated with regulated facilities, estimates impacts, and defines emergency response protocols.

  A NJDEP Chemical Safety Engineer will review and approve the covered processes in two phases:

  - Pre-construction Safety Review: NJDEP Chemical Safety Engineer reviews design and planning documents to ensure that the system is designed in accordance with applicable codes and standards.
  - Pre-startup Safety Review: before the covered process comes online, NJDEP reviews any changes to the documentation and performs a detailed on-site audit of all risk management procedures. This includes the management system, prevention program, and emergency response program.

Operations also will comply with applicable U.S. and NJ Homeland Security regulations as well as Coast Guard regulations.

3.7.4 *Vessel Traffic Associated with Operations of the Marine Terminal*

A variety of cargo vessels are expected to call on the marine terminal. The drafts of the cargo vessels would range from 30 feet to 40 feet, with a maximum length of approximately 868 feet and maximum width of approximately 151 feet. Because a vessel would be at the berth for approximately two days during loading/unloading, vessels may call on the facility no more frequently than one every other day. Vessels would use the Federal navigation channel to move to and from the site.

For the marine terminal, annual cargo ship calls were estimated for each of the projected cargo commodities. It is estimated that a maximum of 133 cargo ships would annually call to the marine terminal. Because of the time needed to load and unload a vessel and ready it for departure, a vessel would be at berth for approximately two days; therefore no more than two to three vessels could call on the terminal in a given week, which results in an average of approximately 2.75 vessel calls per week.

As summarized on Table 3-6, the USACE expects that of the 133 vessels calling on the marine terminal per year, 42 will be vessels that, absent the construction and operation of this facility, would have otherwise visited other terminals that already exist along the Delaware River; therefore, these 42 vessels will not be new traffic in the river but rather a redistribution of existing traffic on the river. The remaining 91 vessels are expected to be new vessels that would not otherwise have visited the Delaware River except for the operation of the new marine terminal. The basis that the USACE used for these projections is presented in sections 3.7.4 and 3.9. Based on the information provided in the biological assessment, availability of berth space is not the fundamental driver for the number of vessels transiting the Delaware River and calling on ports. The regional demand for commodities drives the number of vessels calling on regional ports; therefore, the supply of berth space does not create demand for vessels. The market demand for commodities drives shipments to meet demand for the commodities. Accordingly, an assumption critical to the analysis of vessel traffic is that the market demand for commodities does not change as a direct result of the construction of the marine terminal.

Table 3-6. Projected annual vessel calls at the proposed Marine Terminal.

Commodity	**Annual Volume**	**Units**	**Vessel Capacity**	**Number Of Vessels (annual)**	**Redistributed Vessel on the Delaware River?**	**New Annual Vessel Trips on the Delaware River (inclusive of upriver and downriver transits)**
RoRo	100,000	UNITS	1,100	91	Not Redistributed	182
Break-Bulk	130,715	MT	12,000	11	Redistributed	0
Crude Oil	4,800,000	BBL	400,000	12	Redistributed	0
Refined Product	5,400,000	BBL	400,000	13	Redistributed	0
Liquid Gases	2,400,000	BBL	400,000	6	Redistributed	0
ALL	**12,830,715**		**Total**	**133**	**-**	**182**

The cargo and vessel types expected to use the proposed marine terminal are:

- *RoRo*: The projected 91 vessels that carry RoRo cargo would not be traffic redistributed from existing ports. The proposed project provides a new berth that is capable of handling RoRo and is expected to create a new port opportunity on the Delaware River. While RoRo terminals presently exist on the Delaware River at the Port of Philadelphia and Port of Wilmington, and vessels presently calling at these ports may also call on the proposed marine terminal, a conservative scenario assumes that these vessels would only call on the marine terminal.
- *Break-Bulk*: For vessels associated with break-bulk goods, a reasonable conservative scenario is that these vessels would replace vessels destined for other ports on the Delaware River. As reported in the BA, currently the existing regional ports (i.e., Port of Wilmington, Packer Avenue Terminal downstream of the proposed marine terminal and Penn Terminal across the river from the proposed marine terminal) that handle break bulk are overburdened and not able to efficiently handle the volume of goods that are destined for the region. DRP provides a new berth that would relieve the over-crowding at these other regional ports. This would not result in new vessels calling on the other regional ports, but would reduce vessel queueing.
- *Crude Oil, Refine Product and Liquid Gases*: Vessels calling on the proposed marine terminal are expected to support existing storage and distribution of raw materials and products associated with existing refineries on or in close proximity to the Delaware River; thus these vessels already exist on the River. These refineries include PBF Energy (Paulsboro, NJ), Philadelphia Energy Solutions (Philadelphia, PA, on the Schuylkill River), Monroe Energy (Marcus Hook, PA) and PBF Energy (Delaware City, DE)
    - For these commodities, vessels are presently transiting to one of the existing refineries on the Delaware River. Because those refineries have finite handling capacity, when a vessel is destined for one of these refineries, it must stop at an anchorage point to wait for a slot at the receiving dock to be available. The marine terminal would provide a new berth that would allow that vessel to reduce anchorage time and unload sooner. From the marine terminal, these commodities would be distributed by truck. The marine terminal would offer a more efficient and cost-effective solution for these commodities and create value for the refineries without-increasing the number of ships actually transiting the Delaware River.

Accordingly, the proposed marine terminal provides additional capacity for handling products within an existing supply chain. The addition of the proposed marine terminal to the region facilitates handling of existing commodities already transiting the Delaware River, but does not increase demand for those commodities, and thus would not increase the number of vessels entering the Delaware River to offload commodities other than for RoRo cargo.

3.8 Description of Proposed Mitigation and Conservation Measures

The applicant in conversation with us has committed to complete dredging and pile driving by April 1, 2018, to avoid effects to larval Atlantic sturgeon and shortnose sturgeon. We have agreed to push back the time-of-year restrictions in 2018 from March 15 to April 1 to avoid larval exposure to stressors from pile driving and hydraulic dredging.

In a letter from the USACE to us dated December 6, 2017, the USACE indicates that the following proposed Special Conditions that will avoid or minimize effects to Atlantic sturgeon and shovelnose sturgeon will be included if the USACE should issue a permit for the development of the proposed marine terminal:

- Construction activities shall not result in the disturbance or alteration of greater than 27 acres of waters of the United States.

3.8.1 *Construction*

During pile driving and construction activities, the following measures will be implemented to avoid or minimize effects to listed species and critical habitat.

- Time of year restrictions for any in-water construction work other than pile driving from March 15 – July 15;
- A vibratory hammer shall be used to initially install all piles until pile refusal is reached. At this point, an impact hammer type pile driver can be utilized to drive all piles to their final design depth;
- In order to reduce hydro-acoustic impacts on fisheries resources during pile driving, a wooden cushion cap shall be placed on pile heads during pile driving;
- A bubble curtain shall be installed as shown on the plans entitled" ... Concept Bubble Curtain " prepared by Weeks Marine Incorporated, dated November 17, 2017, last revised November 20, 2017, sheets 1 and 2 of 2 to minimize impacts to fisheries resources during pile driving;
- To minimize impacts to the fisheries resources, a "soft start"[3], which involves having the hammer (both vibratory and impact) commencing work at half power, shall be employed, for a minimum of 15 minutes. After this time period, the hammer can be used at full power; and,
- Limit pile driving to no more than 12 hours per day.

3.8.2 *Dredging*

- A monitoring protocol for the 2.1 acres of SA V Bed B shall be presented to the USACE Philadelphia District office for review and approval within 60 days of the date of the permit. Dredging cannot commence at the site until the monitoring protocol is approved by the office; and,
- For the initial dredging event, dredging is prohibited within 500 feet of the SAV Bed B, as described in the August 2017 Submerged Aquatic Mitigation Proposal prepared by Ramboll Environ and shown in Figure 3-6 between July 15 and October 31.

For material that has been determined to be contaminated per New Jersey Department of Environmental Protection standards.

- An environmental bucket shall be used for the removal of accumulated sediment at the site. The permittee shall monitor the descent of the bucket, and ensure that it is used in

[3] The biological assessment for this project indicates a "soft start" procedure for vibratory drivers will be to initiate sound for fifteen seconds at reduced energy followed by a thirty-second waiting period. This procedure will be repeated two additional times. Reduced energy "soft start" for impact drivers will be to provide an initial set of strikes at reduced energy, followed by a thirty-second waiting period, then two subsequent reduced energy strike sets. Reduced energy "soft start" will be implemented at the start of each day's pile driving and at any time following cessation of pile driving for a period of one hour or longer.

such a manner that the bucket will not penetrate beyond the vertical dimension of the bucket. The permittee shall minimize the loss of sediment due to extrusion through the bucket vent openings and hinge area;

- Controlling the rate of descent of the bucket to maximize the vertical cut of the clamshell bucket while not penetrating the sediment beyond the vertical dimension of the open bucket (i.e., overfilling the bucket). The dredging contractor would use appropriate software and sensors to ensure consistent compliance with this condition;
- In order to minimize sedimentation of the waterway during removal of accumulated sediment, the environmental bucket shall be operated in a manner that will minimize the number of passes required to remove the sediment and shall not be dragged over the substrate. Additionally, the rate of removal of the bucket from the river shall be performed at a rate no greater than 2 feet per second; and
- Dredged material shall be placed in water tight and/or solid hull construction barges in order to prevent spillage of material overboard. The gunwales of the dredge scows shall not be rinsed or hosed during dredging except to the extent necessary to ensure the safety of workers maneuvering on the dredge scow. All decant water within the scows shall be held without physical disturbance a minimum of 24 hours, or for a lesser time if testing can demonstrate that total suspended solids (TSS) meets the background level of 30 mg/l, based on three consecutive TSS analyses. Once either of these criteria have been met, the decanted water shall be returned to the Delaware River where the excavated material was removed.

For any dredged materials that are not considered contaminated per New Jersey Department of Environmental Protection standards the following special conditions shall be followed:

- Any hydraulically dredged material pumped via pipeline to the Whites Basin CDP shall be placed within a basin located on the upland portions of the facility. The material shall not be discharged directly into the re-handling basin; and,
- In the event that the permittee selects to dispose of any dredged materials at the Fort Mifflin CDP, the permittee shall obtain a Water Quality Ce1tificate (WQC) from the Pennsylvania Department of Environmental Protection (P ADEP) prior to any disposal activities. It is the permittee's responsibility to ensure that all material to be placed at the Fort Mifflin CDP site shall meet all requirements, including a site specific Water Quality Certification, from the PADEP.

The applicant further propose that if hydraulic dredging is used, the outlet at the dredged material receiving site would be monitored to determine if sturgeon are entrained. If entrainment is observed, all in-water work would stop and the contractor would contact the USACE and NMFS to determine the next course of action.

The biological assessment also includes the following measures to avoid and minimize effects:

- Use of shallow draft construction vessels that maximize the navigational clearance between the vessel and the river bottom where practicable;
- Vessel travel to and from the proposed berth will use the Federal navigational channel when applicable; and,

- Vessels approaching the berth will not exceed two knots and vessels leaving the proposed berth will operate at speeds of less than ten knots.

3.8.3 *Operations*

Operation of the marine terminal would employ the following safety and environmental protection measures:

- An operations shed would be provided near the loading platform, with ESD, controls, instrumentation, communications, and alarm systems. It is expected that a semi-permanent containment boom would be positioned immediately landward of the outboard row of piles. A reeled deployable containment boom will be provided to encircle tanker vessels after mooring. The booms would be secured via boom slot, to accommodate variations in river level due to tidal fluctuations.
- On the berth structure, the stormwater runoff generated by a 10-year storm event would drain via sheet flow and two trench drains. The stormwater would leave the trench drains and enter a closed storm drain system. The closed storm drain system would convey the stormwater to an oil/water separator. Oil and solids collected in that device would be periodically removed and properly disposed off-site. Separated water would be conveyed to the landside stormwater management system described below.
- The stormwater management system is designed so that proposed development will meet 50% TSS removal for all redeveloped impervious coverage and 80% TSS removal for all new impervious cover as required by the New Jersey Stormwater Management Rules (N.J.A.C. 7:8).

Operation of the marine terminal would be subject to several regulatory programs that provide guidance, regulation, and approval of plans that would provide for spill and leak prevention, spill containment in the event of release and safe operation of the facilities. These regulatory programs include the U.S. EPA’s Oil Spill Prevention and Preparedness Program, Clean Water Act National Pollutant Discharge Elimination System Permit Program (administered by NJDEP), NJDEP Discharge Prevention Program, and NJDEP Toxic Catastrophe Prevention Act (TCPA) Program:

3.8.4 *Description of Mitigation Required under Other Federal, State, or Local Permits*

As required by the NJDEP issued Waterfront Development, Coastal Wetlands, and Flood Hazard Area permit, mitigation for unavoidable losses to 1.4 acres of intertidal/subtidal shallows and 0.064 acres of Submerged Aquatic Vegetation (SAV) will be performed. Mitigation for intertidal/subtidal shallows will be performed through credit purchase at Abbott Creek Mitigation Bank, a USACE-approved bank located on Seabreeze Road in the Township of Fairfield in Cumberland County, New Jersey. Mitigation for impacts to 0.064 acres of SAV that will be required by USACE is currently under review, but will involve creation and/or enhancement within the Delaware River at or in the vicinity of the project site. If feasible, the existing SAV in the 0.064 acre area will be used for the creation/enhancement site. The mitigation plan will meet the requirements of the USACE Mitigation Rule as outlined in 33 CFR 332, published April 10, 2008.

The Applicant has designed the project to avoid disturbing over 100 acres of wetlands within the project site. On June 30, 2017, the NJDEP issued a separate Freshwater Wetlands Individual Permit for the unavoidable disturbance of 4.603 acres of freshwater wetlands and state open waters. Based on a Jurisdictional Determination issued by USACE for the project site on July 5, 2016, impacted freshwater wetlands are not federally jurisdictional. The Applicant will mitigate for the loss of these state-regulated wetlands. Proposed mitigation is the purchase of wetland credits from Willow Grove Mitigation Bank, a NJDEP approved mitigation bank in Vineland, Cumberland County, New Jersey.

3.8.4.1 SAV Mitigation Activities

To mitigate for the loss of the 0.064 acre SAV bed, SAV will be planted in a 0.064 acre area with a similar depth and substrate as existing SAV beds and within close proximity to the project site. Two potential mitigation sites have been identified, Site 1 located 577 feet to the west of SAV bed A within the project area and Site 2, located 715 feet to the east of the SAV bed A and adjacent to the northern extent of SAV bed B (Figure 3-6).

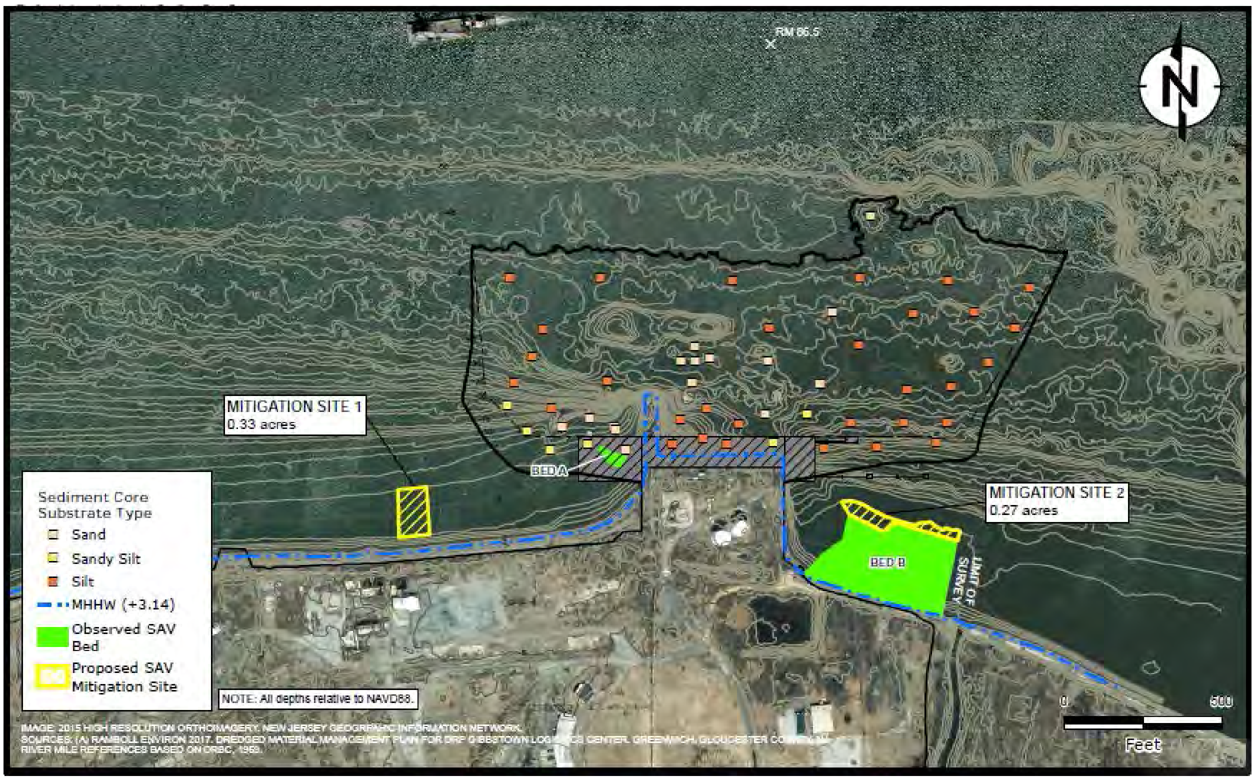

Figure 3-6. Current SAV beds and potential mitigation sites. Originally in RAMBOLL (2017).

Before planting, additional data will be collected to refine boundaries of the mitigation sites and confirm that substrate conditions are appropriate for transplanting. First, scientific divers will visually inspect the mitigation sites to confirm the absence of SAV. Areas with existing SAV will be excluded from further sampling. Second, substrate samples will be collected to determine substrate type, percent sand, and organic carbon content. Third, water quality data will be collected including Secchi disk, depth, turbidity, salinity, dissolved oxygen, and temperature. Data will be collected from a boat and samples will be collected at regular intervals along a transect parallel to the shoreline.

Planting will be accomplished through standard methodologies such as those detailed by the Guidelines for Conservation and Restoration of Seagrass in the United States NOAA's Coastal Ocean Program, 1998 (Fonseca 1998). Plants will be transplanted from the nearby donor SAV bed B or from nursery stock to the selected mitigation site(s) for planting. Plants from bed B will be collected along with their roots and transplanted in the spring. Plants would be harvested using hand tools by divers and transferred to a temporary holding container where they will remain submerged in water to reduce stress and the potential to desiccate. Each mitigation site will have two or more clustered planting areas. Planting areas will be marked with a 5x10 meter grid with 1x1 meter cells. Divers will plant one plant in each grid cell. Planting areas will be clustered within each mitigation site based on site conditions.

As stated in N.J.A.C. 7:7-17.10, "Monitoring and replanting [of SAV] shall be carried out biannually to demonstrate persistence of the compensatory habitat for a minimum of three years." The final SAV restoration sites will be monitored bi-annually in the spring and summer for a period of three years. Monitoring will document density and cover of SAV within the restoration areas and a reference area of SAV bed B. Adaptive management will be conducted as necessary to maintain persistence of compensatory habitat. Adaptive management actions may include replanting, transplanting and seeding.

Planting in the spring could yield a higher probability of mitigation success. A schedule for implementing the mitigation plan is as follows:

- Week of 8/28/17 – Conduct additional data collection
- Week of 9/4/17 – Submit revised SAV mitigation proposal
- Spring 2018 – Harvest plants from bed B
- Spring 2018 – Conduct planting
- Summer 2018 – Monitoring and Adaptive Management
- Spring 2019 – Monitoring and Adaptive Management
- Summer 2019 – Monitoring and Adaptive Management
- Spring 2020 – Monitoring and Adaptive Management
- Summer 2020 – Monitoring and Adaptive Management
- Spring 2021 – Monitoring and Adaptive Management

3.9 Action Area

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area includes the 27-acre project footprint where work to construct the proposed marine terminal will occur (RKM 139.2/RM 86.5) and the area of the river where increased underwater noise levels and changes in water quality will be experienced. The area of the Delaware River channel where turbidity will exceed background levels during dredging will extend 732 meters (2400 feet) upstream and downstream from the project site, and the area of the Delaware River channel that will be affected by elevated noise during pile driving will extend into the river channel at a 100-meter (328-foot) radius from the shore of the terminal site. The action area includes the transit route that barges will use when transporting dredged material downstream to the offloading site at Whites Basin at RKM 132 (RM 82) and upstream to the Weeks Marine site in Camden, New Jersey, at RKM 161.7 (RM 100.5) for upland disposal.

The action area also includes the area where commercial vessels that would not occur but for the proposed marine terminal will travel during operation of the proposed marine terminal. As noted in the project description and based on analysis by the USACE in the biological assessment, only RoRo vessel traffic will be new vessels that would not occur but for the proposed marine terminal. In the biological assessment for this project it is stated that because of the nature of the cargo expected to call on the proposed marine terminal, it is not reasonable to predict at which port they may call first after they arrive in the 200 nautical mile (NM) Exclusive Economic Zone. It is not possible to know whether the ships would travel along the coast from the north or the south, or from any point to the east, before entering the Delaware River. Similarly, the biological assessment has determined that there is no certainty that a vessel entering the ocean shipping lanes in the vicinity of the Delaware Bay will actually travel to and utilize the proposed marine terminal. In an email received on November 17, 2017, the USACE clarified that the RoRo shipping requires no special handling facilities and can be accommodated at any number of port facilities with ample storage and re-handling areas. Therefore, portions of the cargo (usually vehicles) are usually unloaded at various domestic port locations along the coast (*e.g.* Port of Baltimore or Port of New York/New Jersey) depending on the ultimate destinations for those imported vehicles. The USACE has, therefore, determined that it cannot define or predict with certainty at what point when these vessels enters the 200 nautical mile (NM) Exclusive Economic Zone they will enter a specific waterway or navigation channel.

Only when a vessel containing cargo has contracted a Delaware River pilot to pilot the vessel can it be determined that it would call on the proposed marine terminal. This is because the greater Delaware River Port Complex includes commercial cargo facilities in three different states at numerous locations along the Delaware River that continually compete for commercial shipping business. Ports such as the Port of Wilmington, Paulsboro Marine Terminal, Balzano Marine Terminal, Penn Terminals, and Tioga Marine Terminal are located in close proximity to the proposed marine terminal and a cargo vessel may use any of these ports. The pilot boarding area is an approximately 17 square kilometer area located on the ocean side of the COLREGS Demarcation Line[4] at the entrance to Delaware Bay. From there, a vessel traveling to the proposed marine terminal will transit the Precautionary Area[5] before entering the Federal Navigation Channel to travel to the proposed marine terminal or to queue at the Big Stone Anchorage in the Delaware Bay. Commercial vessels may also use any other designated anchorage areas within the Delaware River during transit to or from the proposed marine terminal. Thus, the action area also includes all designated anchorage areas from Big Stone Anchorage in the Delaware Bay up to and including the river Anchorage Area 8 by Little Tinicum Island. Based on information provided by the Applicant, no commercial vessels bound for the proposed marine terminal will travel through the Chesapeake & Delaware Canal because the canal cannot accommodate the deep draft vessels that will use the proposed marine terminal.

Thus, the action area includes the pilot boarding area oceanward of the COLREGS demarcation line; the area between the pilot area and the demarcation line; the regulated Precautionary Area

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[4] A line drawn from Cape May Light to Harbor of Refuge Light; thence to the northernmost extremity of Cape Henlopen (33 CFR 80.503). COLREGS Demarcation Lines delineate those waters upon which mariners shall comply with the Inland and International Rules.

5 As shown on NOAA Chart 12214. Traffic within the Precautionary Area may consist of vessels operating between Delaware Bay and one of the established traffic lanes.

in the Delaware Bay; the Federal navigation channel starting at RKM 8 (RM 5)[6] to the site or the proposed marine terminal at RKM 139.2 (RM 86.5) and including all anchorage areas within this stretch; the site of the proposed marine terminal and the main river channel extending upstream and downstream 760 meters of the site; the Federal Navigation Channel to Camden, New Jersey, at RKM 161.7 (RM 100.5); and staging and access areas at the Whites Basin Sediment Rehandling Facility, Fort Mifflin CDF, and the Weeks Marine site at Camden. Thus the action area starts at RKM 161.7 (i.e., RM 100.5) and ends approximately 11 kilometers (7 miles) into the Atlantic Ocean from the mouth (COLREGS demarcation line) of the Delaware Bay. We anticipate that all effects of the action will occur within this geographic area.

3.9.1 *Description of Habitat Types in the Action Area*

As described above, the action area includes the construction area, dredging area, outfall areas, the Federal navigation channel, and the Atlantic Ocean at the mouth of the Delaware Bay, each of which has variable habitat type, quality, and extent.

3.9.1.1 Construction Area

The construction area consists of the nearshore waterfront portion of the project where the proposed wharf will be constructed. Habitat in the construction area is estuarine freshwater subtidal and intertidal. The slope of the riverbed increases sharply from -5 feet at the shoreline to approximately -35 feet Mean Lower Low Water (MLLW) at approximately 200 feet from the existing wharf edge.

3.9.1.2 Dredging Area

The habitat in the dredging area is estuarine freshwater subtidal and intertidal, with water depths ranging from 0 to -43 North American Vertical Datum of 1988 (NAVD88[7]). The area to be dredged has soft bottom habitat. During typical flow conditions (i.e. non-drought), water salinity is below 0.5 parts per thousand (ppt) (PDE 2012).

Side-scan sonar used during an underwater archaeology study identified four rock piles within the access channel to the existing wharf (Dolan 2017). The piles ranged in area from 1,000 to 2,000 square feet, and were less than three feet high. These generally circular or oblong piles are atypical in the otherwise flat river bottom of the area to be dredged and are believed to be anthropogenic in origin (*e.g.*, ballast or rip-rap used to armor the nearby shoreline). With the exception of the rock piles, hard bottom substrate (*e.g.*, rock, cobble, gravel, limestone, boulder, etc.) is not present within or next to the area that will be dredged. Sediments within the berth area consist of silts and sands, with grain size typically increasing toward the main channel of the Delaware River. In the nearshore area, a silt layer with varying amounts of sands is underlain by a sand layer with trace silt. Some sand lenses occur within and above the silt layers. Further offshore, where the current is greater, very little fine-grained material accumulates, and the bottom surface is dominated by a firm sand layer. Sediment within the Little Tinicum Island Range near the project site is dominated by unconsolidated substrate (Figure 3-7). The nearest

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[6] As determined by the Survey Branch, Operations Division of the USACE, the start of the Federal navigation channel is at 38 54.844 N/-75 5.68962 W, 38 54.908 N/-75 5.49548 W.

[7] The North American Vertical Datum of 1988 (NAVD88) is the vertical control datum of orthometric height established for vertical control surveying in the United States of America based upon the General Adjustment of the North American Datum of 1988.

hard bottom substrate is a rock outcrop on the Pennsylvania side of the river channel, approximately 3 km downstream of the project site near the City of Chester (Figure 3-7).

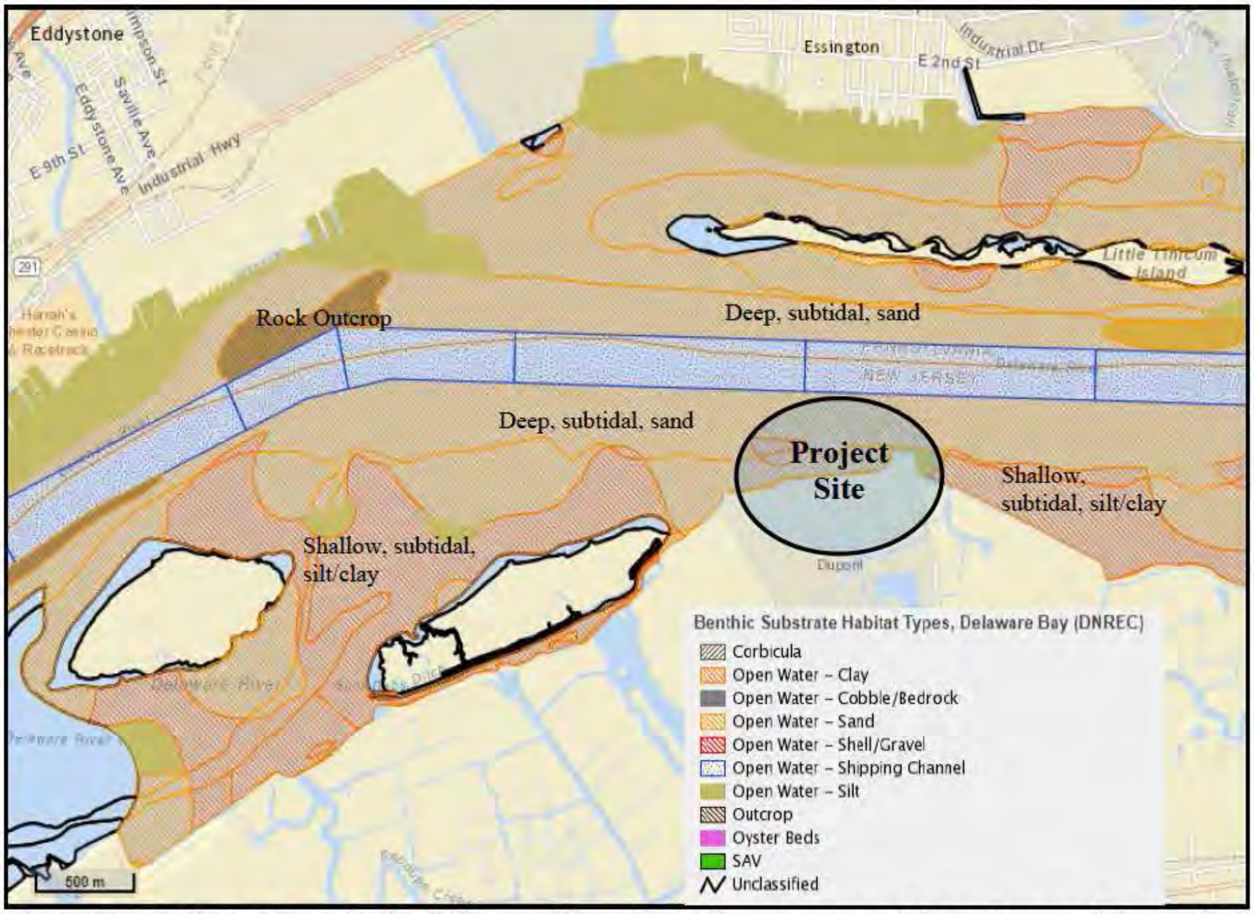

Figure 3-7. Sediment types in the Delaware River channel upstream and downstream of the project site (GIS data by the Delaware Department of Natural Resources and Environmental Control, ERMA 2017).

As described in Section 6.3.2, sediment sampling and analysis within the dredging area indicates that the fine-grained sediments contain concentrations of PAHs, certain metals and PCBs that exceed NJRDCSRS, but only arsenic, chromium and copper exceed the NJDEP freshwater severe effects level ecological screening criteria at a few locations. The coarser-grained material (sand) generally was not impacted.

The SAV survey indicates the presence of two SAV beds within the dredging area. A small area (0.06 ac or 2600 square feet) is located west of the earthen berm and a second larger bed (2.14 acres or 93,284 SF) is located east of the earthen berm.

3.9.1.3 Outfall Areas

Five outfall structures would be installed at 3 locations along the shoreline of the Delaware River. The inlet elevation would be constructed at 2.60 feet NAV88 (i.e., mean high water). Habitat in Outfall Areas consist of soft-bottom substrate with shallow water depths (elevations ranging from -1 to 3.14 feet NAVD88). At low tide, outfall areas are above the water line. Outfall construction would encompass approximately 3,180 square feet of rip rap.

3.9.1.4 Federal Navigation Channel

The bathymetry of the Delaware River is dominated by the navigation channel, which is currently being deepened to 13.7 meters (45 feet). 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. The channel width is 244 meters (800 feet) from the Philadelphia Navy Yard to Bombay Hook (length of 55.7 miles or 89.6 km) and 305 meter (1,000 feet) from Bombay Hook to the mouth of Delaware Bay (length of 44.3 miles or 71.3 km). 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 (RKM 222, RM 138) and Philadelphia (RKM 161, RM 100) 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 (RM 67 to RM 76) (Delaware River Basin Commission 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.

Daily currents measured near the mouth of the Delaware Bay range from 2.5 to 5 fps (NOAA 2015). Mean tidal range measured near Delaware City, Delaware (RKM 96.6, RM 60) was 5.44 feet (NOAA 2017). Moving upstream in the action area, the ratio of tidal flow to net downstream flow is reduced as tidal influence decreases (NMFS 2015). Based on streamflow data collected upstream of the action area, seasonal flows in the Delaware River typically peak in early spring (March – April). Low flow conditions occur in late summer (July – August) (USGS 2017).Tidal flow as measured near the Delaware Memorial Bridge (RKM 108, RM 67.1), 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.

The Federal navigation channel is heavily used by large commercial vessels (*e.g.* tug boats, freight barges, cargo ships, and oil tankers), as well as recreation vessels. The river is bordered by large port facilities of Philadelphia and Camden, as well as large petroleum refineries in Camden and Gloucester Counties (New Jersey) and Delaware County (Pennsylvania). Water depth in the navigation channel ranges from approximately 40 feet to 45 feet MLW. Substrate types vary widely within the channel and span the full range of grain size, from silty clay to gravel to bedrock outcrops (Sommerfield and Madsen 2003).

4 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED BY THE PROPOSED ACTION

4.1 Evaluation of Effects on Species

Although several listed species may be present in the action area, the proposed project being considered in this Opinion is not likely to adversely affect the following species: leatherback, Kemp's ridley and green sea turtles; the Northwest Atlantic distinct population segment (DPS) of loggerhead sea turtle; North Atlantic right whales and fin whales. The rationale for this "not likely to adversely affect" determination is presented below.

North Atlantic green sea turtle	*Chelonia mydas*	Threatened
Northwest Atlantic Ocean DPS loggerhead sea turtle	*Caretta caretta*	Threatened
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
North Atlantic right whales	*Eubalaena glacialis*	Endangered
Fin whales	*Balaenoptera physalus*	Endangered

Listed sea turtles can be present in the Atlantic Ocean, in the Delaware Bay, and in the Delaware River estuary below the Chesapeake & Delaware Canal (C&D Canal) at RKM 94.3 (RM 58.6). Listed whales are present in the Atlantic Ocean and could be present within the Delaware Bay. These species are not present in the Delaware River at the project site or at any of the identified dredge material disposal facilities. Therefore, the only activity that may affect listed species of sea turtles and whales is commercial vessel activity once the proposed marine terminal is operational. The effects of vessel traffic on sea turtles and whales are discussed below.

4.1.1 *Status of Sea Turtles in the Action Area*

4.1.1.1 Species Description and Life History

In the U.S. Atlantic waters, sea turtles commonly occur throughout the inner continental shelf from Florida to Cape Cod, MA. The recognized life stages for sea turtles are egg, hatchling, juvenile/subadult, and adult (Hirth 1971). Reproductive cycles in adults of all species involve some degree of migration in which the animals return to nest at the same beach year after year (The Marine Turtle Recovery Team 1984).

Along the Atlantic U.S. coast, leatherback, green and loggerhead sea turtle nesting beaches occur from Virginia south through Florida. A few green and loggerhead sea turtle failed nesting attempts have occurred on Delaware and New Jersey beaches but these are believed to be abnormalities. Beaches in the two states do not support regular nesting of either species. Kemp's ridley turtles nesting occur as a synchronized mass nesting behavior in in the state of Tamaulipas, Mexico, where nearly 95% of worldwide Kemp's ridley nesting occurs. Some Kemp's ridley turtle nesting occurs in the Gulf, especially along the coast of Texas.

Once in the surf, hatchlings exhibit behavior known as "swim frenzy," during which they swim in a straight line towards the open sea for many hours (Carr 1986). It is not known where this time is spent once into the waters off the nesting beach but hatchlings may become associated with floating sargassum rafts offshore. Once they grown in size, juveniles reenter coastal waters. Since turtle nesting do not occur within the action area or on nearby beaches, no hatchlings will be present within the action area.

In winter, adult and juvenile sea turtles are found along the southern U.S. Atlantic coast. As water temperatures warm in the spring, they begin to migrate northward from their southern nesting beaches to forage within their northern foraging grounds arriving in Virginia waters as early as April/May and on their more northern foraging grounds in New England by June. This trend is reversed in the fall as water temperatures cool with most sea turtles leaving New England by fall. Juveniles and, to a lesser extent, adult sea turtles may be found foraging within New Jersey state coastal waters including the Delaware Bay during these times, .

The functional ecology of sea turtles in the marine and/or estuarine ecosystem is varied. The loggerhead is primarily carnivorous and has jaws well-adapted to crushing mollusks and crustaceans, and grazing on encrusted organisms attached to reefs, pilings and wrecks. The Kemp's ridley is omnivorous and feeds on swimming crabs and crustaceans. Juvenile green sea turtles are primarily carnivorous, and more mature specimens eat marine animals, particularly cnidarians, mollusks, crustaceans, sponges and jellyfish, along with vascular sea grass. Adult green turtle is an herbivore and grazes on marine grasses and algae while the leatherback is a specialized feeder preying primarily upon jellyfish. Detailed information concerning the individual life history, distribution and biological requirements for each of the individual species of sea turtle can be found on the NOAA office of Protected Resources webpage at http://www.nmfs.noaa.gov/pr/species/turtles/index.html and is incorporated here by reference.

4.1.1.2 Presence within the Action Area

The action area is outside the range of sea turtle nesting; therefore, no eggs or hatchlings will be present. Adult and juvenile sea turtles do occur within the Atlantic Ocean, the Delaware Bay, and the Delaware River estuary (Stetzar 2002). The upper range within the Delaware River estuary is considered Artificial Island at RKM 87 (RM 54) due to low salinity above this point; however, sea turtles occasionally occur as far up as the mouth of the Chesapeake & Delaware Canal (C&D Canal) at RKM 94.3 (RM 58.6). As such sea turtles presence in the action area includes the navigation channel in the Delaware River downstream of the C&D Canal; the Big Stone Anchorage and Precautionary Area in the Delaware Bay; and the pilot area in the Atlantic Ocean including the open waters between the pilot area and the Precautionary Area. Sea turtles arrive in the mid-Atlantic from southern overwintering areas in May and typically begin migrating southward by mid-November. Thus, sea turtles could be exposed to in- and outbound RoRo vessels between May through November.

4.1.2 *Status of Whales in the Action Area*

Endangered North Atlantic right and fin whales may occasionally occur within the lower portions of Delaware Bay and the portion of the Atlantic Ocean that overlaps with the action area.

4.1.2.1 Species Description and Life History

Fin whales have a maximum length of approximately 75 feet in the northern hemisphere and 85 feet in the southern hemisphere. Fin whales show mild sexual “dimorphism,” with females measuring 5-10% longer than males. Adults can weigh between 80,000-160,000 pounds (40-80 tons). Fin whales live in social groups of two to seven whales and in the North Atlantic; they are often seen feeding in large groups that include humpback whales, minke whales, and Atlantic white-sided dolphins (Jefferson *et al.* 2015). During the summer, fin whales feed on krill, small schooling fish (*e.g.*, herring, capelin, and sand lance), and squid by lunging into schools of prey with their mouth open. Fin whales fast in the winter while they migrate to warmer waters.

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics. They occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally.

Based on the fin whale Stock Assessment Report, the best abundance estimate available for the western North Atlantic fin whale stock is 1,618 (CV=0.33; Hayes *et al.* 2017). This estimate is derived from the 2011 NOAA shipboard surveys and represents the most current data, though the survey does not include all of the stock's range (Anonymous 2017).

North Atlantic right whales are large baleen whales. Females are larger than males. Right whales generally feed from spring to fall, though they may also feed in winter in some areas. Their primary food sources are zooplankton, including copepods, euphausiids, and cyprids. Right whales feed at or just below the water's surface and at depth –sometimes close to the ocean bottom. They primarily occur in coastal or shelf waters, although movements over deep waters are known. Right whales migrate to higher latitudes during spring and summer (NMFS 2005).

North Atlantic right whales experienced substantial decline during the whaling period and may have been reduced to fewer than 100 individuals by 1935 when international protection for right whales came into effect (Hayes *et al*. 2017). By 1990, the population was estimated to 270 individuals and estimated abundance continued to climb to 483 individuals by 2010. The population has since continued to decline with an estimated 458 individuals by 2015 (Pace *et al.* 2017). Pace *et al.* (2017)found that of special concern was the finding that the reduced of adult females relative to adult males have produced divergent abundance trends between sexes. Since June 7, 2017, at least 15 right whale mortalities have occurred, the majority in Canadian waters, triggering NMFS to declare an Unusual Mortality Event under the Marine Mammal Protection Act (NMFS 2017a).

In the mid-Atlantic, adult and juvenile right whales occur throughout the continental shelf and slope waters, possibly off shore of New Jersey and Virginia. NMFS established Seasonal Management Areas (SMAs) in 2008 to reduce the likelihood of death and serious injuries to endangered right whales that result from collisions with ships (73 FR 60173). The areas are defined as the waters within a 20-nm area with an epicenter located at the midpoint of the COLREG demarcation line crossing the entry into the designated ports or bays. A mid-Atlantic SMA is located at the mouth of the Delaware River and is active from November 1 through April 30 of any given year. Vessels 65 feet or longer are required to operate at speeds of 10 knots or less when traveling through the SMA. Federal regulations, as specified at 50 CFR 222.32, requires that a vessel to steer a course away from a right whale and immediately leave the area at a slow safe speed if a whale is observed within 500 yards (460 m) of the vessel.

4.1.2.2 Presence within the Action Area

Fin and right whales occur throughout the continental shelf and slopes of the mid-Atlantic (NMFS 2017c). In addition, right whale sightings have been documented at the mouth of the Delaware Bay and in a few rare occasions within the bay. Right whales are most likely to occur in waters off the New Jersey coast between November 1 and April 30 as they migrate between northern foraging and southern calving grounds (NMFS 2017d). Adult and juvenile fin whales could theoretically be present within the action area in the Delaware Bay or at its mouth but they have never been observed in these waters. Given the lower salinity and shallower depths than marine waters, right and fin whales are not present in the lower Delaware River. Based on best available information, we have determined that within the action area fin whales and right whales could be present in the navigation channel in the Delaware Bay; the Big Stone Anchorage and Precautionary Area in the Delaware Bay; and in the pilot area in the Atlantic Ocean including the open waters between the pilot area and the Precautionary Area.

4.1.3 *Effects of Vessel Traffic on Sea Turtles and Whales*

Collision with vessels remains a source of anthropogenic mortality for sea turtles and whales. project-related vessels would increase vessel traffic in the action area. Despite being one of the primary known sources of direct anthropogenic mortality to whales and a cause of mortality to sea turtles, vessel strikes remain relatively rare, stochastic events, and an increase in vessel traffic in the action area would not necessarily translate into an increase in vessel strike events. In this subsection, we evaluate whether this increase in vessel traffic would increase the risk of vessel strikes to listed species.

4.1.3.1 Sea Turtles

Interaction with project vessels could injure or kill sea turtles. Interactions between vessels and sea turtles are poorly understood; however, collisions appear to be correlated with recreational boat traffic (NRC 1990) and the speed of the vessel (Hazel *et al.* 2007, Sapp 2010). Sea turtles are thought to be able to avoid injury from slower moving vessels, since the animal has more time to maneuver and avoid the vessel (Sapp 2010). 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 (Stetzar 2002). As noted above, the majority of sea turtle mortalities occur as a consequence of interaction with recreational vessels. While we do not have an estimate of the number of recreational and small fishing vessels in the action area, we do know that a substantial number operate on the bay. Further, the recreational boating activity is likely concentrated during the typical boating season (May to September) which corresponds to the period when sea turtles are present. In addition to recreational vessels, a median of 42,000 commercial vessel trips (up- and downbound) occur in the navigation channel each year (see section 6.3.3). Even if only commercial vessels were to be considered as the cause of sea turtle mortality and assuming that they are evenly distributed throughout the year such that half of the vessel trips occur during turtle season, the likelihood of an interaction between a sea turtle and any one of the commercial vessels transiting the Federal navigation channel is extremely low. In general, sea turtles are thought to be able to avoid large cargo vessels or to be pushed out of the impact zone by propeller wash or bow wake (NMFS 2013).

As discussed in Section 3.7.4, the proposed marine terminal will add 91 RoRo vessels to the action area that would not occur but for the project. Thus, 182 new annual vessel trips will be added to the baseline when the marine terminal is in operation. The projected increase in traffic represents an approximately 0.43% increase of commercial vessel trips in the Federal navigation channel.[8] The actual increase in vessel traffic over the baseline conditions would be even less, considering that commercial vessels is only a portion of the vessel traffic in the river. Further, not all the 91 RoRo vessels will occur during sea turtle season since the terminal can only handle an average of 2.75 vessels per week. Thus the proposed marine terminal will be able to handle only about 66 RoRo vessels assuming all the vessels seek dock during sea turtle season (six months). Given the small increase in vessel traffic when added to baseline vessel activity and the baseline rarity of strikes, any increase in the risk of a vessel striking a sea turtle would be so small that it cannot be meaningfully measured, detected, or evaluated; therefore, effects to sea turtles are insignificant.

4.1.3.2 Whales

Vessel strikes represent a source of anthropogenic mortality for whales and are one of the primary threats to the recovery of right whales (Conn and Silber 2013, Laist *et al.* 2001, Van Der Hoop *et al.* 2013). Laist *et al.* (2001) reported that the most lethal or severe injuries are caused by vessels greater than 262 feet in length and traveling at speeds greater than 14 knots.

Presence of right whales occasionally occur in the lower Delaware Bay from November to April; however, no right whales have been observed inland of the COLREGS Demarcation Line at Delaware Bay since 2002 (NMFS 2017d). However, though unlikely, it is possible that migrating adult and juvenile whales may be seasonally present within the Delaware Bay. Since vessels bound for the marine terminal may enter and transect the Delaware Bay at any time of the year and the proposed marine terminal will be able to only handle an average of 2.75 vessels per week, not all of the 91 RoRo vessels will occur within the action area during the time when whales might be present.

Whales are most likely to be hit by vessels traveling at speeds of 10 knots or more (Laist *et al.* 2001, Pace and Silber 2005, Vanderlaan and Taggart 2007). Therefore, we established Seasonal Management Areas (SMAs) in 2008 to reduce the likelihood of death and serious injuries to endangered right whales that result from collisions with ships (50 CFR 224.105). The areas are defined as the waters within a 20-nm area with an epicenter located at the midpoint of the COLREG demarcation line crossing the entry into the designated ports or bays. A mid-Atlantic SMA is located at the mouth of the Delaware River and is active from November 1 through April 30 of any given year. Vessels 65 feet or longer are required to operate at speeds of 10 knots or less when traveling through the SMA. In addition, federal regulations, as specified in 50 CFR 222.32, requires that a vessel steer a course away from a right whale and immediately leave the area at a slow safe speed if a whale is observed within 500 yards (460 m) of the vessel. Thus, measures to avoid vessel strike are already in place and will be applicable to the 91 new RoRo vessels.

Given that the project will result in only 91 new RoRo vessels that will enter the action area; that the whales would be present within the action area only seasonally if at all; that only a portion of the 91 RoRo vessels will enter the action area when whales might be present within the action area; the existence of federal regulations to avoid vessel strike; and the rarity of whales in the Atlantic Ocean at the mouth of Delaware Bay and within the Delaware Bay, we find it extremely

[8] Refer to Section 5.3.3.1 for a discussion of baseline vessel traffic within the Delaware River.

unlikely that a RoRo vessel on its way to or from the proposed marine terminal will interact with a whale. Thus, effects of vessel traffic on whales are discountable.

4.2 Evaluation of Effects on Critical Habitat

The action area does not overlap with the areas designated as critical habitat for the North Atlantic right whale or any sea turtle species. Thus, the proposed marine terminal will not affect any designated critical habitat for these species. We have not designated critical habitat for shortnose sturgeon. Thus, none will be affected.

On August 17, 2017, we issued a final rule designating critical habitat for the five DPSs of Atlantic sturgeon (82 FR 39160). The rule became effective on September 18, 2017. The action area overlaps with 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.

Here, we consider whether the development and operation of the proposed marine terminal may affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon.

4.2.1 *New York Bight DPS: Delaware River Critical Habitat Unit*

As described above, the Delaware River critical habitat unit extends from the Trenton-Morrisville Route 1 Toll Bridge at approximately RKM 213.5 (RM 132.5), downstream to where the main stem river discharges into Delaware Bay at approximately RKM 78 (RM 48.5). Thus, the portion of the action area from Weeks Marine in Camden, NJ, at RKM 161.7 (RM 100.5) downstream to the mouth of the river with the Delaware Bay (RKM 78; RM 48.5) overlaps with critical habitat. The critical habitat designation is bank-to-bank within the Delaware River. While the action area overlaps with critical habitat from RKM 78-161.7, it does not encompass the full river length of critical habitat within the Delaware River Unit

In this analysis, we consider the direct and indirect effects of the construction activities and operation of the terminal (an interrelated action) on each of four physical and biological features (PBF) of the critical habitat. For each PBF, we identify the activities that may affect the PBF. For each feature that may be affected by the action, we then determine whether effects to the feature are insignificant, discountable or entirely beneficial. In making this determination, we consider the action's potential to affect how each PBF supports the species 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.

The PBFs identified in the final rule 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).

All four PBFs occur within the action area for the proposed marine terminal considered in this Opinion.

4.2.1.1 Physical and Biological Feature 1

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.

The Delaware River Basin Commission (DRBC) 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 3 (Delaware River Basin Commission 2017). In the biological assessment for this project, the USACE noted that the median monthly salt line location is between RKM 107.8 and 122.3 (RM 67 and 76) and that typical salinities within the Dredging and construction areas (at RKM 139.2/RM 86.5) range from 0 to 0.5 ppt. However, the USACE 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 2009c). 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.

While, to date, eggs and larvae of Atlantic sturgeon have not been collected in the Delaware River, 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, Fisher 2009, 2011) 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, RM 77.7-85.8) indicates that these are likely areas of high quality spawning habitat that are regularly selected by adult Atlantic sturgeon.

Therefore, the stretch of river where spawning is likely to occur (i.e., RKM 125-212, RM 77.7-131.7) overlaps with the location of the proposed marine terminal (at RKM 139.2, RM 86.5), the reach of the river where construction vessels will travel (RKM 134-162, RM 83 – 100.5), and the stretch of river above the salt line where commercial vessels will travel to and from the terminal during operation (RKM 107.8-162, RM 67-86.5).

Hard bottom substrate in low salinity waters (i.e., ≤ 0.5 ppt) is present in several locations within the action area:

- **Federal Navigation Channel**: outcrops of bedrock, boulders, cobble, rock and gravel exist in the channel. USACE has been blasting bedrock in the navigation channel from RKM 123-136 to complete the deepening project (see section 6.1.2.3), and we know spawning is likely to occur, potentially on some of the hard bottom substrate in the channel, between RKM 125-138. According to DNREC data hosted on ERMA (2017), there are several other outcrops of bedrock in the navigation channel in the action area.
- **Anchorage Area 7 at Marcus Hook**: in reviewing substrate data for anchorage areas upstream of the salt front that may be used by vessels interrelated/interdependent on the construction of the proposed Terminal, we conclude that Anchorage Area 7 (~RKM 126-131) has hard bottom substrate that Atlantic sturgeon could potentially use for spawning, refuge, growth, and development. Data provided in ERMA (2017) also supports the conclusion that this area contains a hard bedrock outcrop that has the potential support Atlantic sturgeon spawning.
- **Anthropogenic rock piles (ballast or rip-rap) within the access channel to the existing wharf at the proposed Terminal construction site**: These four piles range in area from 1,000 to 2,000 square feet, and are less than three feet high. These piles are surrounded by soft sediments (silts and sands), some of which are contaminated (USACE 2017a).

Dredging and construction activities will potentially affect all three of these locations. Below, we consider if the locations meet the criteria of PBF 1, and whether or not the development of the proposed marine terminal will adversely affect the critical habitat feature.

<u>Hard Bottom Substrate in the Federal Navigation Channel and Anchorage Area 7:</u>

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.

In reviewing the best available information, we believe the outcrops of hard bottom substrate in the navigation channel, particularly between (RKM 125-138), as well as Anchorage Area 7 at

Marcus Hook likely support Atlantic sturgeon spawning, refuge, growth, and development, and therefore, meet the criteria for PBF 1. Project related activities that may affect these areas include vessel traffic in the navigation channel and anchorage area, anchoring at the anchorage area, and dredging at the project site. Mechanical dredging at the project site will not directly remove hard bottom substrate from these areas, and will occur outside of the time of year we expect spawning and use of PBF 1 by eggs and larvae to occur (April 1 – September 30). However, it may produce a sediment plume extending up to 732 m upstream or downstream, and sediments from these activities could potentially settle on exposed hard bottom substrate meeting the criteria for PBF1 within the navigation channel. Similarly, vessels using the navigation channel and Anchorage Area 7 may disturb and resuspend bottom sediments during movements and the placement of anchors, and these sediments could settle on hard bottom substrate. We expect water velocities that keep hard bottom habitat exposed during pre-activity, baseline conditions, 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 and vessel traffic/anchoring turbidity plumes on PBF 1 are extremely unlikely to occur, and are discountable. While it is possible that an vessel anchoring in Area 7 could drop anchor onto an area of hard bottom substrate while the area is in use for spawning or the refuge, growth, and development of early life stages, the likelihood of the anchor, which would affect an extremely small area (i.e., several square feet), interacting with hard bottom substrate in the same space and time as the habitat supports spawning sturgeon or early life stages (i.e., between April 1 and September 30) are extremely unlikely. We do not expect anchoring to remove or diminish the value of hard bottom substrate in Anchorage Area 7, as any minor disturbance would not negatively affect the quality or distribution of hard bottom substrate or interstitial spaces. Therefore, direct adverse effects from anchoring on hard bottom substrate on PBF 1 are discountable.

Anthropogenic Rock Piles at the Project Construction Site

As described in the description of the action area, side-scan sonar used during an underwater archaeology study identified four rock piles within the access channel to the existing wharf (USACE 2017a). The piles range in area from 1,000 to 2,000 square feet, are less than three feet high, and the USACE's best estimate is that they originated from discarded shipping ballast and/or collapsed rip-rap. These piles are extremely small in area (less than 0.2 acres combined) and are isolated areas of rocks surrounded by soft substrate (sands and silts, some of which are contaminated) close to shore where there used to be a retaining wall. The fact that naturally occurring exposed hard bottom substrate does not exist elsewhere in the access channel suggests that the water velocities in this near shoreline area are not high enough to keep naturally occurring hard bottom substrate clear of soft sediment deposits (the four piles appear to be built up high enough to remain above the mudline). The accumulation of sediment in this area is supported by the proposal to maintenance dredge the access channel approximately once every 10-15 years. Optimal flows for Atlantic sturgeon spawning are 46-76 cm/s, and sufficient water depths and flow are necessary to adequately hydrate and aerate newly deposited eggs, as well as facilitate successful development and downstream migration of the newly spawned Atlantic sturgeon (see section 5.1.2). We would not expect Atlantic sturgeon to select a spawning site that does not have sufficient flows. Furthermore, we assume that if the side-scan sonar suggests the rocks were potentially used for rip-rap, that they are fairly large and uniformly sized. Therefore, it is extremely unlikely that a pile of such rocks would have the small interstitial spaces preferred by sturgeon for spawning and refuge, growth, and development of larvae.

While these piles of rocks could theoretically be used for spawning, 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 isolated 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 rock piles contain hard substrate in low salinity water, 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.

4.2.1.2 Physical and Biological Feature 2

In examining 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. 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 RKM 107.8 is a reasonable approximation given the lack of real time data. 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 approximately 29,430 acres. We used DNREC's shapefile data "Delaware Bay Upper Shelf Bottom Sediments 2008-2010" (Metadata created 2015) to determine a ratio of soft bottom substrate to hard bottom substrate in the areas they surveyed between RKM 78-107.8: 78% unconsolidated sediments; 22% reef/hard bottom. Without additional information, we assume all unconsolidated sediments defined by DNREC may consist of soft substrates (*e.g.*, sand, mud). We make 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. With that assumption, we 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. Of this, the Federal Navigation Channel constitutes approximately 8.5% of the area where we expect PBF 2 to occur (assuming that all of the navigation channel has soft substrate).

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 expect 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 lifestage), 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). Thus, the river channel between RKM 78 and RKM 107.8 contains soft substrate for juvenile foraging and physiological development.

The proposed marine terminal is located at RKM 139.2 (RM 86.5) and effects of construction activities – including transit by construction vessels, pile driving, and dredging of the berth – will occur between RKM 132 (RM 82) and RKM 161.7 (RM 100.5). This is above the upstream limit (at RKM 107.8) of PBF 2. Thus, PBF 2 is not present at the site of the proposed marine terminal or within the river reaches of the action area where effects from construction activities will be present; however, effects of vessel traffic navigation includes this reach of the Delaware River, the action area to the mouth of the Delaware Bay, and includes portions of the Federal navigation channel between RKM 78 and 107.8 that meet the definition of PBF 2. Over the 30-year life span of the proposed marine terminal, the project would add to the existing vessel traffic another 91 RoRo vessels or 182 vessel trips per year that would not occur if not for the development of the marine terminal. Further, vessels heading for the proposed marine terminal may use anchorage areas 2 through 5. Here we consider whether those activities may affect PBF 2 and if so, whether those effects are adverse or insignificant, discountable or entirely beneficial when added to baseline.

Soft substrate may be disturbed by large, deep draft, commercial vessels as they travel the Delaware River or during the use of federal anchorage areas. For example, propeller jet, shear stress, and/or the hull touching the river bottom by vessels operating with limited underkeel clearance and propellers close to the bottom surface may scour the riverbed of the navigation channel or contribute to a localized increase in turbidity. Further, anchoring of vessels in designated anchorage areas that are located downstream of the salt line may affect PBF 2 if the soft bottom substrate is impacted by anchoring activities in a way that impacts its ability to support juvenile foraging and physiological development. Anchors may scour the substrate as they are placed on or dragged over the bottom and the strong swirling jet flow induced by rotating ship propellers during positioning and movement can scour the riverbed and suspend sediment particles (see section 8.2.4.1). Scouring of the riverbed and resuspension of sediment 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 expose benthic invertebrates and improve foraging opportunities. The extent to which the disturbance of soft sediments by vessels passing through these areas occurs 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.

The RoRo vessels will have a maximum of 40-foot draft while the navigation channel will have a depth of 45 feet. Thus, we expect little, if any, scouring of soft bottom habitat or increased resuspension of fines will occur since the RoRo vessels going to or from the proposed marine terminal will have a minimum draft clearance of 5 feet. Further, RoRo cargo destined for the proposed terminal may be dispersed throughout the year, only one RoRo vessel can dock at the terminal at any one time, and each vessel needs at least two days for handling. Therefore, we expect the operation of the proposed terminal to add at most three vessels to existing vessel traffic during a one week period. Any effects from a RoRo vessel will be temporary and of short duration. Assuming the vessels move at a speed of 10 knots, then they will use less than two hours to traverse critical habitat (29.8 km of the navigation channel) where PBF 2 is present. Assuming six vessel trips (three up and three downbound) per week, each taking two hours, then the RoRo vessels (that would not occur but for the operation of the terminal) will operate in the navigation channel where PBF 2 is present about 7% of a 24-hour-seven-week period.

Therefore, considering a worst-case scenario, RoRo vessels would be present 7% of the time over approximately 8% of PBF 2 (within the navigation channel). As discussed in section 6.3.3, the Federal navigation channel is already highly trafficked with a median of 42,300 registered vessel trips (up- and downbound) per year between 2005 and 2015. Of these, a median of 2,193 vessel trips (min 1,982 trips, max 2,774 trips) per year were vessels with a draft exceeding 30 feet. Given that the proposed marine terminal will only increase vessel traffic by approximately 0.4 %, and that the minimum of 5-foot draft clearance will minimize any disturbance of bottom substrate by hull or propeller, any increase in disturbance of soft substrate within the navigation channel from the RoRo vessels, when added to baseline, will be so small that it cannot be meaningfully measured, detected, or evaluated. Therefore, any effect to the value of soft substrate within the navigation channel for juvenile foraging and physiological development by the addition of the RoRo vessels is insignificant.

There are four federal anchorages between RKM 78 and 107.8. Of these four anchorages, only Anchorage 3 and 5 have a depth that would accommodate 40-foot draft vessels and also have a primary unconsolidated benthic substrate (ERMA 2017). Anchorage 3 is approximately 1.49 km^2 (368 acres) large and Anchorage 5 is approximately 0.98 km^2 (242 acres). These two anchorage areas represent about 2 percent of all critical habitat within the Delaware River that has PBF 2 present. Anchorage areas are largely used by commercial vessel traffic. More than 40,000 vessel trips by commercial vessels occur in the Delaware River each year. Though not all vessels use these two anchorages areas, it is likely that the frequent traffic present throughout the year have degraded the value that the soft bottom substrate within the two anchorages have for juvenile foraging or physiological development. The project would add 91 vessels or 182 vessel trips per year to the baseline traffic, though it is not expected that all 91 vessels will use Anchorage 3 or 5 as use of anchorages depends on vessel traffic and queuing of vessels moving up or down the Delaware River. We assume that the same proportion of the 91 RoRo vessels will use the anchorage as the proportion of the baseline number of vessels in the Delaware River that use the anchorages. Further, while a vessel may anchor in any section of an anchorage area, the anchors only cover a few square meters and a single vessel will only disturb a small fraction of the total area constituting the anchorage areas. The area affected by a vessel will depend on the size of the vessel and the extent of activity necessary to position the vessel for anchoring. Thus, over the course of a year, the 91 RoRo vessels are expected to disturb a fraction of soft substrate within each of the two anchorage areas. If all vessels anchored within one of the two anchorage areas, all vessels anchored both during the up- and the downbound trip (i.e., 182 trips), no vessel set anchor at the same location as any of the other RoRo vessels, and all vessels were of the large size described in the biological assessment, then the vessels would cover a total of 2.2 km^2 or 90 percent of the two anchoring areas. Anchoring activities are expected to disturb soft bottom habitat but will not alter or change the substrate type.

The use of the two anchorages by RoRo vessels will negatively affect PBF 2 and will contribute to the feature's inability to improve in value in the future as the repeated disturbance of substrates during anchoring will interrupt the establishment and succession of benthic invertebrates in these areas that juvenile Atlantic sturgeon would otherwise feed on. However, only 91 RoRo vessels will be added annually to the baseline traffic of over 40,000 annual commercial vessel trips, only some of these 91 RoRo vessels are expected to use the two anchorages, not all will use the two anchorages at the same time but be dispersed throughout the year, and these anchorage areas represents about two percent and a non-continuous amount of available soft substrate in the action area. Considering these factors, the effects of the project on the value of PBF 2 in the action area to support juvenile foraging and 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.

4.2.1.3 Physical and Biological Feature 3

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 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.

No portion of the action area is dammed, and the movement of sturgeon is unimpeded to and from spawning sites; therefore, PBF 3 is present within the action area. 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.*, low DO) 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 site of the proposed marine terminal and vessel transit routes. Here we consider whether those activities may affect PBF 3 and if so, whether those effects are insignificant, discountable, or entirely beneficial.

The proposed marine terminal involves construction of a pile-supported wharf and associated structures. The proposed wharf would extend approximately 28 meters (93 ft.) from the shoreline and the river is approximately 915 meter (0.7 miles) wide at this location (between the terminal (NJ) and Little Tinicum Island. A shallow approximately 490 meter wider channel is also present between Little Tinicum Island and Pennsylvania river bank; therefore, the proposed Action would not create a physical barrier to movement of sturgeon. Project activities, such as dredging and noise from construction, may cause sturgeon to temporarily avoid the active work area, but these activities would be temporary and would not prevent sturgeon from accessing areas farther upstream. Both dredging and pile driving will occur outside of the spawning period and will not affect the upstream movements of mature adults to spawning sites. Claymont and Marcus Hook, PA may provide important overwintering and nursery grounds for juvenile and YOY sturgeon. Traffic transiting to and from the proposed marine terminal during construction would be constrained to the dredging area (i.e. the area between the berth and Federal navigation channel), and to the Federal navigation channel, which is already a highly trafficked waterway. Dredging would increase water depths in a small portion of the action area, but otherwise would not affect water depth within the Delaware River. Based on this information, the proposed marine terminal is extremely unlikely to affect unimpeded movements of Atlantic sturgeon. Any effects to the value of PBF 3 to the conservation of the species are discountable.

4.2.1.4 Physical and Biological Features 4

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.

Baseline water quality in the action area is described in 6.3.1. Based on this information, PBF 4 exists in the action area downstream from the Weeks Marine Camden to where Delaware River empties into the Delaware Bay. Flow, temperature, and DO are likely to be highly spatially and temporally variable throughout the action area. Pile driving will have no effects on water temperature, salinity or dissolved oxygen. The proposed Action would result in a small increase in vessel traffic over baseline conditions but vessels will not alter the salinity, dissolved oxygen, and temperature of water in the Delaware River. Bottom water temperatures in the dredging area and construction area may decrease slightly because of increased depth and shading from the wharf, but these changes in water temperatures at the scale of the river channel would be so small they could not be meaningfully measured, detected or evaluated within the temporal and spatial variation in water temperatures of the river channel. Stormwater discharges from the upland marine terminal would be monitored under discharge limits set by the NJDEP. Discharge limits set by the state are expected to be protective of aquatic life stages, including sturgeon. Considering these factors, the effects of the project on the value of PBF 4 in the action will be so small that they cannot be meaningfully measured, evaluated, or detected. Therefore, any effects to the value of PBF 4 to the conservation of the species are insignificant.

4.2.2 *Summary of effects to critical habitat*

We have determined that effects to PBF 1 and PBF 3 are extremely unlikely to occur and are therefore discountable or cannot be meaningfully measured, detected, or evaluated and are therefore insignificant. Effects to PBF2 and PBF 4 will be so small that they are not able to be meaningfully measured, detected or evaluated and are therefore insignificant. Therefore, all effects of the proposed marine terminal on the Delaware River critical habitat unit are insignificant and discountable. Critical habitat designated for the NYB DPS does not include areas currently not used by Atlantic sturgeon and, therefore, no unoccupied critical habitat exists within the action area. 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. Based on this, the action is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon. This concludes consultation on the effects of the action on critical habitat designated for the New York Bight DPS of Atlantic sturgeon.

5 STATUS OF LISTED SPECIES IN THE ACTION AREA

Information on species' life history, its habitat and distribution, and other factors necessary for its survival and recovery are included to provide background for analyses in later sections of this Opinion. Information on the status of these species are found in a number of published documents including recent recovery plans, status reviews, stock assessment reports, and technical memorandums. Many are available at http://www.nmfs.noaa.gov/pr/species/. The summaries below provide a foundation for our evaluation of the effects of the proposed action on the listed species. We have determined that the actions being considered in the Opinion may affect the following listed species[9]:

Common name	Scientific name	ESA Status
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Gulf of Maine DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Threatened
New York Bight DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered

9 We use the word "species" as it has been defined in section 3 of the ESA, which include "species, subspecies, and any distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature (16 U.S. C 1533)." Any DPS is a "species" for the purposes of the ESA

Chesapeake Bay DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Carolina DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
South Atlantic DPS of Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered

The status of the species (as defined by the ESA) is determined by the degree that it (1) maintains sufficient genetic and phenotypic diversity to ensure continued fitness in the face of environmental change, (2) maintains spatial distribution of populations so that not all populations would be affected by a catastrophic event, and (3) maintains sufficient connectivity among populations within a DPS to maintain long-term demographic and evolutionary processes (McElhany *et al.* 2000, Spence *et al.* 2008). We describe the current condition of the spatial structure and major life histories within the species or DPSs. In order to maintain a spatial distribution and diversity that support a viable species or DPS, a species must maintain multiple viable populations that are sustainable in the long-term in the face of environmental variability.

5.1 Sturgeon

Sturgeon are ray fined fish that belong to the order Acipenseriformes. The Acipenseriforms contain two families, *Acipenserida* (sturgeon) and *Polydontidae* (paddlefish). Acipenseriformes likely evolved between the late Jurassic and early Cretaceous geological periods (70 to 170 million years ago) and, therefore, are often referred to as a "living fossils." The word sturgeon likely originated from the European derivative "sturio" or "stirrer". These words likely refer to the sturgeon feeding habits of stirring up the bottom of lake and rivers in which they inhabit to feed. Nine of the 28 sturgeon species (family *Acipenserida*) listed by the World Sturgeon Conservation Society (http://www.wscs.info/) are found in North American inland lakes and oceanic waterways. Three of these species are found in rivers along the U.S. east coast: lake sturgeon, shortnose sturgeon, and Atlantic sturgeon. The latter two are listed under the Endangered Species Act. Studies of Acipenseriformes phylogeny place lake sturgeon and shortnose sturgeon as closely related and distinct from Atlantic sturgeon, which the phylogenies place as a primitive form (Krieger *et al.* 2008, Ludwig *et al.* 2001).

Internally, the skeleton is cartilaginous with bones only present in the skull, jaw and pectoral girdle. Shortnose sturgeon and Atlantic sturgeon are physostome fish, meaning that the swim bladder is connected to the intestinal tract by a special duct, which allows for regulation of gas pressure via swallowing air or releasing air through the gut.

5.1.1 *Shortnose Sturgeon*

5.1.1.1 Description

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. More thorough discussions can be found in the cited references as well as the SSSRT's Biological Assessment (2010). Detailed information on the populations that occur in the action area is provided in section 6.4 while details on activities that impact individual shortnose sturgeon in the action area can be found in section 6.

5.1.1.2 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.

The life stages of shortnose sturgeon can be divided up into six general categories as described in the Table 5-1 below.

Table 5-1. Descriptions of shortnose sturgeon life history stages.

Stage	Size (mm)	Duration	Behaviors/Habitat Used
Eggs	3-4	13 days post spawn	Stationary on bottom; cobble and rock, fast flowing freshwater
Yolk Sac Larvae	7-15	8-12 days post hatch	Photonegative; swim up and drift behavior; form aggregations with other yolk sac larvae; cobble and rock, stay at bottom near spawning site
Post Yolk Sac Larvae	15-57	12-40 days post hatch	Free swimming; feeding; silt bottom; freshwater
Young of Year (YOY)	57-140 (north); 57-300 (south)	From 40 days post-hatch to one year	Deep, muddy areas upstream of the salt wedge
Juveniles	140 to 450-550 (north); 300 to 450-550 (south)	One year to maturation	Increasing salinity tolerance with age; same habitat patterns as adults
Adults	450-1,100 average; (max recorded 1,400)	Postmaturation	Freshwater to estuary with some individuals making nearshore coastal migration

Shortnose sturgeon live on average for 30-40 years (Dadswell *et al.* 1984). Males mature at approximately 5-10 years and females mature between age 7 and 13, with later maturation occurring in more northern populations (Dadswell *et al.* 1984). Females typically spawn for the first time 5 years post-maturation [age 12-18; Dadswell (1979), (Dadswell *et al.* 1984)] and then spawn every 3-5 years (Dadswell 1979, Dadswell *et al.* 1984). Males spawn for the first time approximately 1-2 years after maturity with spawning typically occurring every 1-2 years (Kieffer and Kynard 1996; NMFS 1998; Dadswell *et al.* 1984). 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 2012). Shortnose sturgeon spawn in freshwater reaches of their natal rivers when water temperatures reach 9–15°C in the spring (Dadswell 1979, Kynard 1997, Taubert 1980a, Taubert 1980b). Spawning occurs over gravel, rubble, and/or cobble substrate (Buckley and Kynard 1985, Dadswell 1979, Kynard 1997, Taubert 1980a, Taubert 1980b) 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 1979, Dadswell *et al.* 1984). 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) (Holland and Yeverton 1973; Saunders and Smith 1978). 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.

Shortnose sturgeon feed on benthic insects, crustaceans, mollusks, and polychaetes (Dadswell *et al.* 1984, 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 (Buckley and Kynard 1985, Dadswell *et al.* 1984, O'Herron *et al.* 1993).

In northern rivers, shortnose aggregate during the winter months in discrete, deep (3-10m) freshwater areas with minimal movement and foraging (Kynard *et al.* 2016). 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 1997, Weber 1996). 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 (Rogers and Weber 1995). Older juveniles typically occur in the same overwintering areas as adults while young of the year remain in freshwater (Kynard *et al.* 2016).

5.1.1.3 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 (see Catesby 1734; McDonald 1887; 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.

5.1.1.4 Current Status

There is no current total population estimate for shortnose sturgeon rangewide. 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 1998, 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 (Kynard *et al.* 2016). 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/Che sapeake Bay and Southeast groups function as metapopulations[10]. 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 (see Grunwald *et al.* 2002, Waldman *et al.* 2002, Walsh *et al.* 2001, 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.

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[10] 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.

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 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 (Fernandes 2008, Fernandes *et al.* 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; Squires *et al.* 1982). A population study conducted 1998-2000 estimated population size at 9,488 (95% CI = 6,942 -13,358; 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 1998, Kynard *et al.* 2012, 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 1980a). Using four mark-recapture methodologies, the longterm 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%. 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 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 (Hastings *et al.* 1987, ERC 2006). 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 are no shortnose sturgeon between Maryland waters of the 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.

5.1.1.5 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; Wirgin *et al.* 2000) 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 (Anders *et al.* 2002; 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.

5.1.1.6 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.

5.1.2 *Atlantic Sturgeon*

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon and then provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also provide a description of which Atlantic sturgeon DPSs likely occur in the action area and provide information on the use of the action area by Atlantic sturgeon.

The Atlantic sturgeon (*Acipenser oxyrinchus* oxyrinchus) is one of two subspecies of *A. oxyrinchus*, the other being the Gulf sturgeon, *A. o. desotoi*. It is distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (ASSRT 2007, Scott *et al.* 1988). 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 5-1). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment. 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 (Wirgin *et al.* 2015a, Wirgin *et al.* 2015b). Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

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

The section below provides life history information that is relevant to all DPSs of Atlantic sturgeon. As described below, individuals originating from any of the five listed DPSs are likely to occur in the action area. Information specific to each of the relevant DPSs, is provided below.

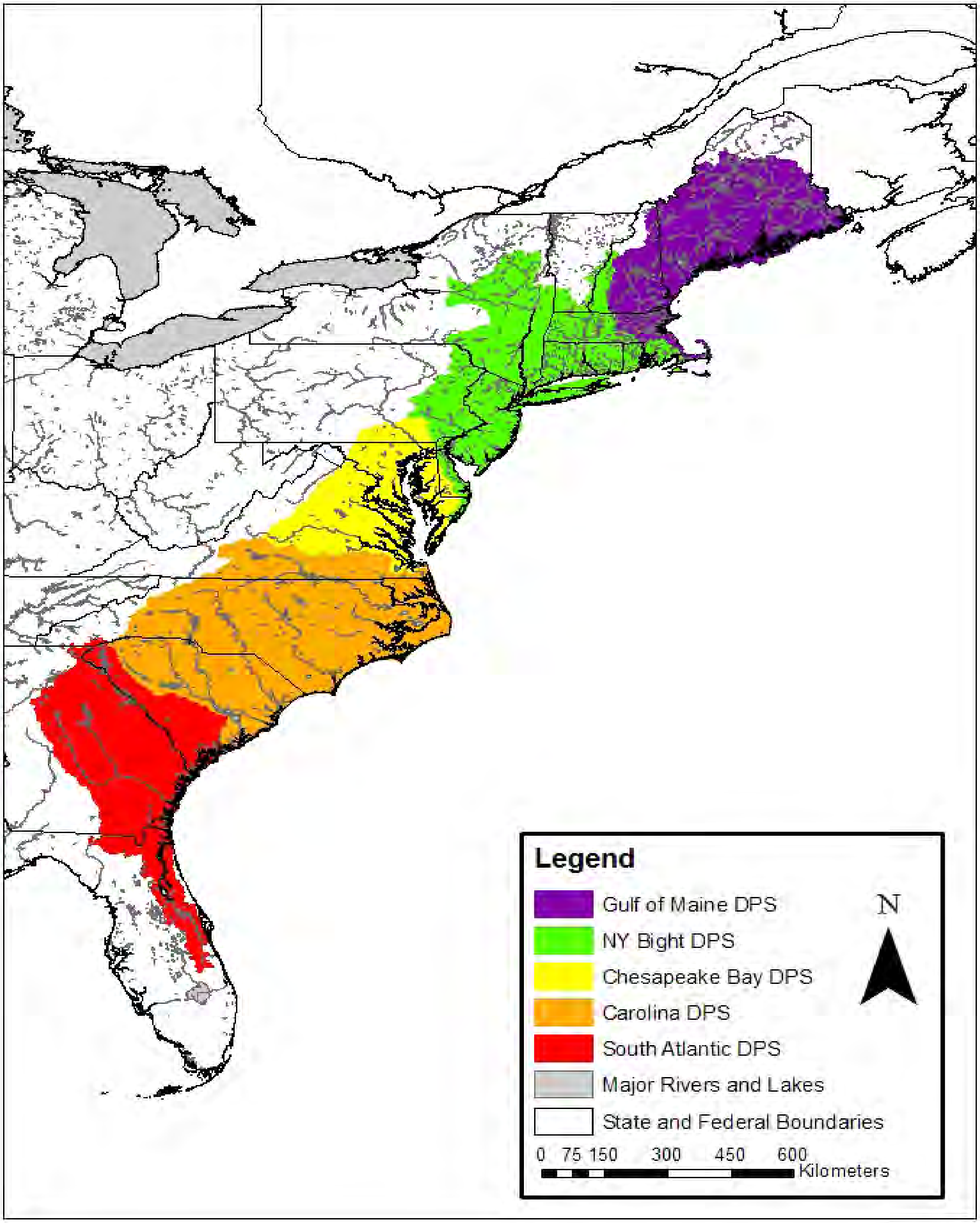

Figure 5-1. Map depicting the five Atlantic sturgeon DPSs.

5.1.2.1 Life History and General Habitat Use

The Atlantic sturgeon is a long-lived (approximately 60 years), late maturing, estuarine dependent, anadromous[11] fish (ASSRT 2007). They are a relatively large fish, even amongst sturgeon species (Pikitch *et al.* 2005). It grows slowly, eventually reaching 1.5 to 1.8 meter (5 to

[11] Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn.

6 feet) in length as adults. Once mature, they still continue to grow, and the largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.3 m (14 feet)(Vladykov and Greeley 1963). Males weigh up to 41 kg (90 pounds) and females weigh up to 73 kg (160 pounds).

In appearance, they are bluish-black or olive brown dorsally (on their back) with paler sides and a white belly. They have no scales, but five rows of scutes (bony plates) cover their head and body: one along the back, one on either side and two along the belly. Its long, hard snout has an upturned tip, with four sensory barbels on the underside of its snout. Its mouth is located on the underside (ventrally-located) of the head, is protruding (can be withdrawn and extended as an accordion), soft and toothless. The mouth generally measures less than half the distance between the eyes (or distance between the lateral margins of the bony skull) (Damon-Randall 2010). Atlantic sturgeons are bottom feeders that use the protruding mouth to pick up food (Bigelow and Schroeder 1953). The four chemosensory barbels in front of the mouth assist the sturgeon in locating prey.

The life stages of Atlantic sturgeon can be divided up into six general categories as described in the Table 5-2 below.

Table 5-2. Descriptions of Atlantic sturgeon life history stages.

Age Class	Size	Description
Egg	~2 to 3 mm diameter	Fertilized or unfertilized
Yolk Sac Larvae	~6 to 14 mm TL	Negative phototaxis, nourished by yolk sac (endogenous feeding)
Post Yolk Sac Larvae	~14 to 37 mm TL	Positive phototaxis, free swimming, actively feeding (exogenous feeding)
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
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

Spawning

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 the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m)

(ASSRT 2007, Caron *et al.* 2002, Collins *et al.* 2000, Dadswell 2006, Kahnle *et al.* 2007, Scott *et al.* 1988, Smith 1985, Smith *et al.* 1982, Smith *et al.* 1984). 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.

The number of eggs produced of females range from 400,000 to approximately 8 million depending on body size (and age) (Hilton *et al.* 2016, Van Eenennaam and Doroshov 1998, Van Eenennaam *et al.* 1996). Therefore, observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). Multiple studies have shown that spawning intervals range from 1-5 years for males (Caron *et al.* 2002, Collins *et al.* 2000, Smith 1985) and 2-5 for females (Dadswell 2006, Stevenson and Secor 1999, 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). 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 they are mature.

Though Atlantic sturgeon spend most of their life in the marine environment, spawning occurs in the freshwater portion of flowing rivers and is believed to occur between the salt front of estuaries and the fall line of large rivers (ASSRT 2007). However, the spawning areas in most U.S. rivers have not been well defined.

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) (Dovel and Berggren 1983, Smith 1985, Smith *et al.* 1982), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren 1983, Smith 1985), make rapid spawning migrations upstream, and quickly depart following spawning (Bain 1997).

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. Based on these observations, spawning is likely to occur on hard bottom substrate such as cobble, coarse sand, and bedrock when and where optimal flows are 46-76 cm/s and depths are 3-27 m (Bain *et al.* 2000, Borodin 1925, Caron *et al.* 2002, Collins *et al.* 2000, Hatin *et al.* 2002, Hilton *et al.* 2016, Shirey *et al.* 1999).

Eggs and Larvae

Sturgeon females deposit their eggs on the hard bottom substrate at the spawning site (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009). Atlantic sturgeon egg diameter is smaller than for shortnose sturgeon eggs, approximately two to three millimeter after fertilization (Hardy and Litvak 2004, Van Eenennaam *et al.* 1996). The eggs become adhesive shortly after fertilization (Mohler 2003, Murawski and Pacheco 1977). Incubation time for the eggs increases as water temperature decreases (Mohler 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT 2007).

Hatchlings (called free embryos) have a yolk sac that provides nourishment (endogenous feeding) during the first stage of larval development. Hatchlings are assumed to undertake a demersal existence, seek cover in the bottom substrate and yolk sac larvae (i.e. free embryos less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam *et al.* 1996) are assumed to inhabit the same riverine or estuarine areas where they were spawned (Bain *et al.* 2000, Kynard and Horgan 2002). The free embryo exhaust the yolk sac and become larvae after about eight days (Kynard and Horgan 2002).

Juvenile Atlantic sturgeon nurse above the salt front in river estuaries and early life stages, therefore, need to migrate downstream from spawning areas. In a laboratory study by Kynard and Horgan (2002), post yolk sac larvae derived from Hudson River parents emerged from cover, initiated swim-up and drift behavior, and immediately started feeding. The larvae continued to swim up in the water column and exhibit drift behavior for up to 12 days with the peak number of larvae migration occurring at day five. During the first days of migration, emergent larvae drifted passively in the current and seemed to be mostly nocturnally active while during the latter half of migration the larvae actively swam with the current and were active day and night.

Sturgeon larvae are free swimming and typically concentrate in deep channel habitat during drifting/migration to nursery habitat (Bath *et al.* 1981, Braaten *et al.* 2010, Smith and King 2005). However, Usvyatsov *et al.* (2013) did not find that shortnose sturgeon larvae had any consistent pattern of larval distribution across the channel but they did observe a clumped distribution indicating that most larvae observed a similar drift pattern within the channel. This suggested that the larvae where exposed to and followed similar hydrological forces. Because of local morphology, engineered structures, and diverse flow hydraulics, larvae should be more laterally and longitudinal dispersed as they drift from spawning areas (*e.g.*, pallid sturgeon, Braaten *et al.* 2010, Erwin and Jacobson 2015). Further, younger sturgeon larvae may actively manipulate drift by orienting and swimming against prevailing currents (Rheotaxis) and adjusting buoyance while older larvae swim with currents (Kynard and Horgan 2002, Parker 2007).

Eventually, larvae settle, become demersal, and start foraging in nursery areas above the salt line. Kynard and Horgan (2002) did not observe any additional migration behavior during the 50 days of observation after the larvae settled in an artificial channel. The authors believe that because Atlantic sturgeon spawning areas generally are close to juveniles nursery areas, they exhibit a "one-step" migration that will bring them to the downstream nursery areas. No field studies have been conducted on the demersal larvae stage and we do not know their habitat preferences or where they occur in river channels.

Juveniles

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.* 2007, McCord *et al.* 2007, Munro *et* *al.* 2007) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.* 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (ASSRT 2007, Dadswell 2006, Dovel and Berggren 1983, Waldman *et al.* 1996). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other benthic invertebrates (ASSRT 2007, Guilbard *et al.* 2007) (Bigelow and Schroeder, 1953;).

Subadults and Adults

After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters less than 50 m in depth, using coastal bays, sounds, and ocean waters (Collins and Smith 1997, Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Savoy and Pacileo 2003, Smith 1985, Stein *et al.* 2004b, Wirgin *et al.* 2015a, Wirgin *et al.* 2015b). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (ASSRT 2007, Bigelow and Schroder 1953, Guilbard *et al.* 2007, Savoy 2007,).

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, juvenile Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore fisheries with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (*e.g.*, Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, the mouth of the Delaware Bay, waters off of the coast of New Jersey, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (Dadswell 2006, Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Laney *et al.* 2007, Stein *et al.* 2004b). These sites may be used as foraging sites and/or thermal refuge.

5.1.2.2 Range-wide Status

Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers. 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.

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). 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).

At the time of the listing, there were no current, published population abundance estimates for any of the currently known spawning stocks or for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985 to 1995 (Kahnle *et al.* 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson 2006). Using the data collected from the Hudson and Altamaha Rivers to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year, 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 North East Fisheries Science Center (NEFSC) developed a virtual population analysis[12] model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (see Kocik *et al.* 2013). The objectives was to produce an Atlantic Sturgeon Production Index (ASPI) 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 5-3). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the United States Fish and Wildlife Service (USFWS)

[12] **Virtual population analysis (VPA)** is a cohort modeling technique commonly used in fisheries science. It uses fishery catches to calculate past stock abundances (Coggins *et al.* 2006, Lassen and Medley 2001). It reconstruct historical fish numbers at age using information on death of individuals each year. This death is usually partitioned into catch by fisheries and natural mortality. The VPA is virtual in the sense that the population size is not observed or measured directly but is inferred or back-calculated to have been a certain size in the past in order to support the observed fish catches and an assumed death rate owing to non-fishery related causes. Kocik *et al.* (2013) use fishery bycatch as substitute for fishery catch, data from the United States Fish and Wildlife Service (USFWS) sturgeon tagging database, and published values of life history parameters to produce a virtual population.

sturgeon tagging database[13], 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 5-3). 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 5-3. Description of the ASPI model and NEAMAP survey based area estimate method.

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

Table 5-4. Model 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 population estimates within the area trawled by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 5-5). These are considered minimum estimates because the calculation assumes that the gear will capture (i.e. net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are with the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the

[13] 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.

fraction of the population within the sampling domain. Catchabilities less than 100% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most species and, while the ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, it certainly does not survey 100% of the Atlantic sturgeon habitat.

Table 5-5. Annual minimum swept area estimates with coefficients of variation (CV) for Atlantic sturgeon during the spring and fall from the Northeast Area Monitoring and Assessment Program survey. Estimates assume 100% net efficiencies. Estimates provided by Dr. Chris Bonzek, Virginia Institute of Marine Science (VIMS).

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

Available data do not support estimation of true catchability (i.e., net efficiency X availability) of the NEAMAP trawl survey for Atlantic sturgeon. Thus, Kocik *et al.* (2013) produced and presented the NEAMAP swept area biomass estimates for catchabilities from 5 to 100%. The NEAMAP survey does not include rivers and estuaries. Consequently, YOY and juveniles from these habitats are not included in the population estimate. Although the NEAMAP surveys are not conducted in the Gulf of Maine or south of Cape Hatteras, NC, the NEAMAP surveys are conducted from Cape Cod to Cape Hatteras at depths up to 18.3 meters (60 feet), which includes the preferred depth ranges of subadult and adult Atlantic sturgeon. NEAMAP surveys take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. The NEAMAP estimates are minimum estimates of the ocean population of Atlantic sturgeon based on sampling in a large portion of the marine range of the five DPSs, in known sturgeon coastal migration areas during times that sturgeon are expected to be migrating north and south.

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

The ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey (see Table 5-4). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the U. S. Fish and Wildlife Service (USFWS) sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The NEAMAP estimate, in contrast, does not depend on as many assumptions. For the purposes of this Opinion, we consider the NEAMAP estimate resulting from the 50% catchability rate, as the best available information on the number of subadult and adult Atlantic sturgeon in the ocean.

DPS

Here we use the NEAMAP survey and genetics stock assessment to estimate the subadult and adult population of each DPS. The ocean population abundance of 67,776 fish estimated from the NEAMAP survey assuming 50% efficiency (based on net efficiency and the fraction of the total population exposed to the survey) was subsequently partitioned by DPS based on genetic frequencies of occurrence (Table 5-6) in the sampled area. Given the proportion of adults to subadults in the observer database (approximate ratio of 1:3), we have also estimated a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults.

Table 5-6. Summary of calculated population estimates based upon the NEAMAP Survey swept area assuming 50% efficiency (based on net efficiency and area sampled) derived from applying the Mixed Stock Analysis to the total estimate of Atlantic sturgeon in the Ocean.

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

*As discussed on page 73, genetic testing conducted on Atlantic sturgeon sampled by the NEFOP indicates that approximately 91% 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 5-7. 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)

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 5-7 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[14] 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% chance of being above their 1998 value; however, the index from the Chesapeake Bay DPS (highlighted red) only had a 36% 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% chance of having a mortality rate higher than the threshold. The Gulf of Maine and Carolina DPSs (highlighted red) had 74-75% probability of being above the mortality threshold (ASMFC 2017).

5.1.2.3 *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, Atlantic sturgeon experienced range-wide declines from historical abundance levels due to

14 "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).

overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (ASSRT 2007).

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 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 *et al.* 2012). 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 five 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. The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%.

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; 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). Bain (1997) 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 1^{o}C temperature increase reduced productivity by 65% 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).

5.1.3 *Gulf of Maine DPS of Atlantic sturgeon*

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT 2007). Spawning still occurs in the Kennebec River, and it is possible that it still occurs in the Penobscot River as well. Spawning in the Androscoggin River was just recently confirmed by the Maine Department of Marine Resources when they captured a larval Atlantic sturgeon during the 2011 spawning season below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at 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).

Recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (ASMFC 1998, Squiers *et al.* 1981). 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). 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 (Squiers *et al.* 1979). Following the 1880's, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by-catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (ASMFC 2007, Stein *et al.* 2004b). 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. While Atlantic sturgeon are known to occur in the Penobscot River, it is unknown if spawning is currently occurring or whether the removal of the Veazie and Great Works Dams will result in spawning occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al.* 2006). 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 ASSRT (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 catch per effort (net per day) of subadults from 1998 through 2000 was much greater than that observed in the study conducted from 1977 through 1981 (Squires 2004).

5.1.3.1 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.

5.1.4 *New York Bight DPS of Atlantic sturgeon*

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (ASSRT 2007, Murawski and Pacheco 1977, Secor 2002). Spawning still occurs in the Delaware and Hudson Rivers but was not believed to occur (within the last 15 years) in the Connecticut and Taunton Rivers (ASSRT 2007). However, limited spawning was recently documented in the Connecticut River (Savoy *et al.* 2017) but it is not known if this is rare occurrence or occurs annually. Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007, Savoy and Pacileo 2003).

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800s is unknown but, has been conservatively estimated at 10,000 adult females (Secor 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (ASSRT 2007, Kahnle *et al.* 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). Kahnle *et al.* (2007) and (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 2007, 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 1980s (ASMFC 2007, 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 2009) 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 (Brown and Murphy 2010). Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

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

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

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

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

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

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (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.

5.1.5 *Chesapeake Bay DPS of Atlantic sturgeon*

The Chesapeake Bay DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, VA. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT 2007). Based on the review by Oakley (2003), 100 percent of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e. dams) are located upriver of where spawning is expected to have historically occurred (ASSRT 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (ASSRT 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).

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 as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century (ASMFC 1998, ASSRT 2007, Bushnoe 2005, Secor 2002, Vladykov and Greeley 1963). Habitat disturbance caused by in-river work such as dredging for navigational purposes is thought to have reduced available spawning habitat in the James River (Holton and Walsh 1995; Bushnoe *et* *al.* 2005; ASSRT 2007). At this time, we do not have information to quantify this loss of spawning habitat.

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

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

5.1.5.1 Summary of the Chesapeake Bay DPS

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

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

5.1.6 *Carolina DPS of Atlantic sturgeon*

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

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. We determined spawning was occurring if young-of-the-year (YOY) were observed, or mature adults were present, in freshwater portions of a system. 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 (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. 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.

5.1.6.1 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.

5.1.7 *South Atlantic DPS of Atlantic sturgeon*

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

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, and Satilla Rivers. We determined spawning was occurring if young-of-the-year (YOY) were observed, or mature adults were present, in freshwater portions of a system. 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. The St. Marys River was identified as a spawning river for Atlantic sturgeon based on the capture of YOY Atlantic sturgeon. Atlantic sturgeon were once thought to be extirpated in the St. Marys River. However, nine Atlantic sturgeon were captured in sampling efforts between May 19 and June 9, 2014. Captured fish ranged in size from 293 mm (YOY) to 932 mm (subadult). This is a possible indication of a slow and protracted recovery in the St. Marys (D. Peterson, UGA, pers. comm. to J. Rueter, NMFS PRD, July 8, 2015). The main stem of the St. Marys River runs out well before the fall line. Thus, we believe the upstream extent of spawning habitat in the river is at the confluence of the Middle Prong St. Marys and St. Marys Rivers. Both the St. Marys and St. Johns Rivers are used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. The use of the Broad-Coosawatchie by sturgeon from other spawning populations is unknown at this time. The presence of historical and current spawning populations in the Ashepoo River has not been documented; however, this river may currently be used for nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems utilized by the South Atlantic DPS for specific life functions, such as spawning, nursery habitat, and foraging. However, fish from the South Atlantic DPS likely use other river systems than those listed here for their specific life functions.

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

Threats

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

The modification and curtailment of Atlantic sturgeon habitat resulting from dredging and degraded water quality is contributing to the status of the South Atlantic DPS. Dredging is a present threat to the South Atlantic DPS and is contributing to their status by modifying the quality and availability of Atlantic sturgeon habitat. Maintenance dredging is currently modifying Atlantic sturgeon nursery habitat in the Savannah River and modeling indicates that the proposed deepening of the navigation channel will result in reduced DO and upriver movement of the salt wedge, curtailing spawning habitat. Dredging is also modifying nursery and foraging habitat in the St. Johns River. Reductions in water quality from terrestrial activities have modified habitat utilized by the South Atlantic DPS. Low DO is modifying sturgeon habitat in the Savannah due to dredging, and non-point source inputs are causing low DO in the Ogeechee River and in the St. Marys River, which completely eliminates juvenile nursery habitat in summer. Low DO has also been observed in the St. Johns River in the summer. Sturgeon are more sensitive to low DO and the negative (metabolic, growth, and feeding) effects caused by low DO increase when water temperatures are concurrently high, as they are within the range of the South Atlantic DPS. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the

South Atlantic DPS. Large withdrawals of over 240 million gallons per day mgd of water occur in the Savannah River for power generation and municipal uses. However, users withdrawing less than 100,000 gallons per day (gpd) are not required to get permits, so actual water withdrawals from the Savannah and other rivers within the range of the South Atlantic DPS are likely much higher. The removal of large amounts of water from the system will alter flows, temperature, and DO. Water shortages and "water wars" are already occurring in the rivers occupied by the South Atlantic DPS and will likely be compounded in the future by population growth and potentially by climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient-loading, pollution inputs, and lower DO, all of which are current stressors to the South Atlantic DPS.

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

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

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

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

5.1.7.1 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.

6 ENVIRONMENTAL BASELINE

Environmental baselines for biological assessments include the past and present impacts of all Federal, state, tribal, local, and private actions already affecting the species or that will occur contemporaneously with the consultation in progress. Unrelated Federal actions affecting the same species or critical habitat that have completed formal or informal consultation are also part of the environmental baseline, as are State and other actions within the action area that may benefit or adversely impact listed species or critical habitat. The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of shortnose and Atlantic sturgeon in the action area. The activities that shape the environmental baseline in the action area generally include dredging operations, water quality, scientific research, shipping and other vessel traffic and fisheries, and recovery activities associated with reducing those impacts.

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

Several ESA section 7 consultations have been undertaken to address the effects of actions authorized, funded or carried out by Federal agencies. These actions are detailed below. In some cases the opinions included incidental take statements, which are also detailed below.

6.1.1 *Scientific Studies permitted under Section 10 of the ESA*

The Delaware River population of shortnose and Atlantic sturgeon have been the focus of scientific research for many years. There are currently 17 active scientific research permits pursuant to Section 10(a)(1)(A) of the ESA that authorize research on sturgeon in the Delaware River (NMFS 2017b). Section 10(a)(1)(A) permits authorize activities that enhance a listed species propagation or survival. Sixteen of these permits are set to expire in early 2017 or 2018. Four current permit holders have submitted new permit applications to continue sturgeon research in 2017 and beyond. Mortality of sturgeon from capture in research nets is estimated at 0.03% for shortnose sturgeon and 0.22% for Atlantic sturgeon (since 2012, 14 killed of 6466 captured.) (NMFS 2017b). The following activities are authorized under these permits:

Permit 19331 to Harold Brundage of Environmental Research and Consulting, Inc., for research 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.

6.1.2 *Dredging Operations*

Dredging in riverine, nearshore and offshore areas has the potential to impact aquatic ecosystems by the removal/burial of benthic organisms, increased turbidity, alterations to the hydrodynamic regime and the loss of shallow water or riparian habitat. Dredging may also result in the resuspension of contaminated sediments, potentially exposing aquatic organisms to contaminants in the substrate. According to Smith and Clugston (1997), dredging and filling impacts important habitat features of Atlantic sturgeon as they disturb benthic fauna, eliminate deep holes, and alter rock substrates. Indirect impacts to sturgeon from either mechanical or hydraulic dredging include the disruption of benthic feeding areas, spawning migration, and resuspension of sediments in spawning areas. In addition, hydraulic dredges can directly impact sturgeon and other fish by entrainment in the dredge (ASSRT 2007).

As presented in ASSRT (2007), the Status Review Team for the proposed listing of the Atlantic sturgeon considered dredging to be a moderate risk, as maintenance dredging takes place annually from the Delaware Bay to Trenton, NJ in the Federal navigation channel. Dredging in the upper portions of the river near Philadelphia were considered detrimental to successful Atlantic sturgeon spawning since this area may be historic spawning grounds for the species. Recommended dredging restrictions are in place during the spawning season help to minimize risk, but it is suspected that the continued degradation of the spawning habitat through dredging is likely to increase the instability of the subpopulation (ASSRT 2007).

Dickerson (2006) summarized sturgeon takes from hopper dredging activities conducted by the USACE between 1990 and 2005, resulting in impacts to 24 sturgeon (2 – gulf, 11- shortnose, and 11-Atlantic). Fifteen of these sturgeon were reported dead. Seasonal dredging restrictions help reduce impacts to Atlantic sturgeon and other anadromous fish by restricting dredging activities during sensitive time periods. The 2015 Biological Opinion for the Delaware River deepening project indicated that no sturgeon mortalities were observed as part of the project (NMFS 2015).

In addition, dredging operations may involve blasting of hard rock and may generate construction vessel traffic, both of which may pose a risk to sturgeon. Several consultations have been conducted for dredging activities in the navigation channel of the Delaware River, as described below.

6.1.2.1 Delaware River Philadelphia to the Sea Maintenance Dredging Program

The USACE have conducted annual maintenance dredging of the Delaware River for over 70 years. Maintenance dredging in the river typically occurs between August and December using a hydraulic cutterhead dredge. Dredging in some reaches are conducted by the Federally-owned hopper dredge McFarland. All material excavated from the river is placed in existing upland CDFs located along the Delaware River (USACE 2013).

The Delaware River Philadelphia to Trenton Federal navigation channel is maintained by the USACE. As described in the 2015 biological opinion, a batched consultation was completed in 1996 between us and the USACE on the effects of its authorization and completion of several Federal navigation projects, including the Philadelphia to Trenton project, as well as dredging by other parties requesting a permit from the USACE regulatory program. The biological opinion was reinitiated in 1998 with an amendment issued in 1999 to consider the effects of the maintenance project on shortnose sturgeon and sea turtles. The 1999 biological opinion included an ITS exempting the annual take (entrainment and mortality) of four shortnose sturgeon, four loggerhead, one Kemp's ridley, and one green sea turtle. This take exemption applied to the Philadelphia to Trenton project, maintenance of the 40- foot Philadelphia to the Sea channel, and the USACE regulatory program where private dredging activities are authorized (NMFS 2015).

The USACE prepared a biological assessment in 2013 in relation to the Philadelphia to Sea maintenance program. That assessment was triggered by the listing of Atlantic sturgeon as an endangered species in 2012 and addressed potential impacts to listed species resulting from maintenance dredging within the Delaware River mainstem until the Delaware River Main Channel Deepening project is anticipated to be completed (i.e., in 2018). This assessment concluded that it is possible for Atlantic and shortnose sturgeon to become entrained in the dredge during dredging operations. Maintenance dredging will continue on an annual basis until the Main Channel deepening project is complete (USACE 2013). A biological opinion was issued in 2013. In that opinion, we estimated the following level of incidental take (lethal):

- One Northwest Atlantic DPS loggerhead sea turtle or one Kemp's ridley sea turtle; and
- One shortnose sturgeon; and
- One Atlantic sturgeon from either the GOM, NYB, CB or SA DPS.

The 2013 biological opinion noted that, although listed whales occur seasonally off the Atlantic coast of Delaware and occasional transient right whales have been documented near the mouth of the Delaware Bay, no listed whales are known to occur within the maintenance dredging action area. Therefore, the biological opinion did not discuss impacts to listed whale species.

Your Endangered Species Monitoring Program began in August 1992. Since that time, all hopper dredge operations conducted downstream of the Delaware Memorial Bridge between May and

November have used endangered species observers to monitor for interactions with sea turtles (monitoring for sturgeon was required in the 2013 biological opinion). Two sturgeon were entrained during separate hopper dredge activities in the fall of 2014; the first (10/24/2014) was a fresh dead juvenile Atlantic sturgeon. The second (11/26/2014) was a live Atlantic sturgeon (approximately 12 inches). Several sea turtles have been entrained during hopper dredging operations including two loggerheads in August 1993 and one loggerhead on June 22, 1994.

Relocation trawling was conducted in 1994, and eight loggerheads were captured and relocated away from the channel. On November 13, 1995, one loggerhead was entrained by a hopper dredge working in the channel. On July 27, 2005, fresh loggerhead parts were observed in the hopper basket during two different loads. With the exception of disposal site inspectors working at upland disposal areas, no endangered species observers have been deployed during any cutterhead dredging operations or at any hopper dredge operation for this project (Philadelphia to Sea Maintenance Dredging) upstream of the Delaware Memorial Bridge. (NMFS 2015)

6.1.2.2 Delaware River Philadelphia to Trenton Maintenance Dredging Program

Dredging in the Philadelphia to Trenton project resulted in shortnose sturgeon mortality and may have affected shortnose sturgeon distribution and foraging habitat. In mid-March 1996, three subadult shortnose sturgeon were found in a dredge discharge pool on Money Island, near Newbold Island, Burlington County, New Jersey. The dead sturgeon were found on the side of the spill area into which the hydraulic pipeline dredge was pumping, and the presence of large amounts of roe in two specimens and minimal decomposition indicates that the fish were alive and in good condition prior to entrainment. In January 1998, three shortnose sturgeon were discovered in the hydraulic maintenance dredge spoil in the Florence to Trenton section of the upper Delaware River (see Figure 4-1). These fish also appeared to have been alive and in good condition prior to entrainment (NMFS 2015).

The takes occurred while dredging was conducted in the Kinkora and Florence ranges. This reach overlaps with areas where shortnose sturgeon are known to overwinter in large concentrations. Since dredging involves removing the bottom material down to a specified depth, the benthic environment could be severely impacted by dredging operations. As shortnose sturgeon are benthic species, the alteration of the benthic habitat could have affected sturgeon prey distribution and/or foraging ability. Since 1998, the USACE have been avoiding dredging in the overwintering area during the time of year when shortnose sturgeon are present. Habitats affected by the Philadelphia to Trenton project include foraging, overwintering and nursery habitats. Since 1998, no sturgeon mortalities have been observed (NMFS 2015).

6.1.2.3 Delaware River Stem and Main Channel Deepening Project

The USACE have been working with us since 2008 to consider effects of the deepening of the Delaware River Main Channel, Philadelphia to the Sea Federal Navigation Project. Formal consultation pursuant to Section 7 of the Endangered Species Act of 1973, as amended (ESA) was completed with NMFS's issuance of a biological opinion dated July 17, 2009. This consultation has since been reinitiated three times, with new biological opinions issued on July 11, 2012, January 31, 2014, and November 20, 2015. In the 2015 Biological Opinion, we concluded that the proposed action may adversely affect but is not likely to jeopardize the continued existence of the shortnose sturgeon, the GOM, NYB, CB, and SA DPSs of Atlantic sturgeon, Kemp's ridley and loggerhead sea turtles and is not likely to adversely affect Atlantic sturgeon from the Carolina DPS, green, or leatherback sea turtles. We had not published a final or proposed rule for Atlantic sturgeon designated critical habitat at the time of the biological opinion, and therefore critical habitat was not considered during this evaluation of the project (NMFS 2015).

On December 14, 2015, the USACE sent us a letter requesting reinitiation of the 2015 biological opinion. On January 11, 2016, we returned a letter agreeing that reinitiation was necessary to consider new information revealing effects of the action that may affect listed species in a manner or to an extent not previously considered. On September 13, 2016, the USACE submitted a request for conference, in which the USACE concluded that, although the projects are not likely to destroy or adversely modify proposed critical habitat for Atlantic sturgeon, they are still requesting consultation to consider the both the river deepening and channel maintenance effects on critical habitat. However, we issued a final rule for the designation of Atlantic sturgeon critical habitat on August 17, 2017, and the biological opinion for the project examines effects on designated Atlantic sturgeon critical habitat. This new biological opinion will replace the 2015 biological opinion (Delaware River channel deepening), the 2013 biological opinion (Philadelphia to the sea), and the 1996 biological opinion (Philadelphia to Trenton). Thus, the consultation on the Delaware River channel deepening project includes the Delaware River channel deepening project, Philadelphia to the Sea maintenance dredging, Philadelphia to Trenton maintenance dredging, and the Dredged Material Utilization study.

Summary of Effects of Deepening to Date

As reported in the 2015 Biological Opinion, the Delaware River Stem and Main Channel Deepening Project began in March 2010. Between March and September 2010, approximately 3,000,000 cy of material was removed via cutterhead dredge from Reach C. The disposal site was inspected daily for evidence of entrained sturgeon. No shortnose sturgeon or their parts were observed during the dredging operations. Dredging to execute contract 2, Reach B began in November 2011 and was completed in December 2011 with approximately 1,000,000 cy of material removed. No sturgeon or their parts were observed at the disposal site. Contract 3, deepening of the upper portion of Reach A, was conducted from September 2012 through February 2013. Most dredging was accomplished with a cutterhead dredge, though a hopper dredge was used for a limited amount of the dredging. The total volume removed was 1,259,165 cy. No sturgeon or their parts were observed during dredging or at the disposal sites. Contract 4, deepening of Reach D, was conducted between February and June 2013. The removal of 1,149,946 cy of material was largely completed with a hopper dredge, and with a mechanical dredge in areas where the hopper dredge was not effective. Two takes of Atlantic sturgeon (one live, one dead) were reported during hopper dredging activities in Reach A in 2014 (NMFS 2015). No sturgeon or their parts were observed during hydraulic dredging or at the disposal sites. (NMFS 2015)

In addition to hydraulic dredging, rock blasting activities were conducted on 18 acres in Reach B near Marcus Hook, PA (RKM 123 to RKM 136.2/RM 76.4 to RM 84.6). Approximately 250,000 cy of bedrock and overburden material (i.e. rock debris resulting from the blasting, which will fracture the rock) will be removed to deepen the Federal navigation channel to a depth of 45 feet below meal lower low water. The blasting was conducted by reportedly 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 was removed by a mechanical dredge. The USACE performed relocation trawling before and during blasting activities to minimize the effects of blasting on fish. Since 2014, three Atlantic sturgeon have been killed during relocation trawling activities. Five other takes of sturgeon have occurred due to project rock blasting to date: two Atlantic sturgeon (1 dead; 1 stunned) and three shortnose sturgeon (all dead). A third, final blasting season is scheduled in 2017-2018. Relocation trawling will be performed before blasting.

Maintenance dredging of the 45-ft channel was conducted in areas where shoaling resulted in depths less than 45 ft. One Atlantic sturgeon was observed during maintenance dredging to date (entrained alive in May 2013) (NMFS 2015). No sturgeon mortalities have been observed as part of maintenance dredging for the project to date (NMFS 2015).

The 2017 biological opinion concludes that 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 the biological opinion, we determined that the take are not likely to jeopardize the continued existence of listed species. The biological opinion exempt take incidental to the implementation of the proposed project as follows:

- The lethal take of eight adult or juvenile sturgeon during blasting and relocation trawling in 2017 and 2018. Of the eight, an undetermined fraction will be shortnose sturgeon and an undetermined fraction will be Atlantic sturgeon NYB DBS.
- The lethal take by dredging entrainment/entrapment of up to 83 juvenile and/or adult sturgeon of which all or a fraction will be shortnose sturgeon or Atlantic sturgeon (i.e., an undetermined fraction will be shortnose sturgeon and an undetermined fraction will be Atlantic sturgeon). This take will occur during maintenance dredging from Trenton to the sea over the next 51 years or until 2068.
- Of the 83 sturgeon take, incidental take of up to 48 Atlantic sturgeon New York Bight DPS.
- Of the 83 sturgeon take, incidental take of up to 15 Atlantic sturgeon Chesapeake Bay DPS.
- Of the 83 sturgeon take, incidental take of up to 14 Atlantic sturgeon South Atlantic DPS.
- Of the 83 sturgeon take, incidental take of up to 6 Atlantic sturgeon Gulf of Maine DPS.
- Lethal take of an unquantified number of post yolk sac Atlantic sturgeon New York Bight DPS larvae.
- The lethal take (entrainment) of 26 juvenile Northwest Atlantic DPS loggerhead sea turtles during dredging with a hopper dredge over the next 51 years or until 2068.
- The lethal take (entrainment) of 2 adult and/or juvenile Kemp's ridley sea turtles during dredging with a hopper dredge over the next 51 years or until 2068.

The incidental take statement (ITS) also exempts the capture/collection of up to 1,000 sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon) during relocation trawling project to be carried out over the blasting season (December 1, 2017-March 15, 2018) and the injury (from surgery to install acoustic tags) of up to 100 sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon).

6.1.2.4 *Weeks Marine Inc. Blanket Dredging (CENAP-OP-R-2013-0695)*
The Weeks Marine, Inc. "Blanket" Dredging project consists of two permits, one that would allow for maintenance dredging of 31 port facilities along the Delaware and Schuylkill Rivers, and one that would allow for disposal of dredged material at the Whites Basin dredged material rehandling facility located in Logan Township, Gloucester County, New Jersey. The 31 port facilities are located in New Jersey's Mercer, Burlington, Camden, and Gloucester counties, Pennsylvania's Delaware, Bucks and Philadelphia counties, and Delaware's New Castle County. Maintenance dredging would be conducted by a single contractor (i.e., Weeks Marine Inc.) with mechanical dredges to authorized depths with allowance for two feet of overdraft. The 31 sites constitutes 511 acres of riverbed and would be dredged one or more times over a ten-year period. Dredged material from the 31 sites would be placed into hopper scows and transported to the designated disposal facility. No dredging will take place between March 15 and June 30 of any year.

At the Whites Basin facility, materials are unloaded by bottom-dumping to the open water rehandling basin. After material has accumulated in the basin to an elevation of 7 feet below MLW, the basin is either mechanically dredged to barges or pumped via pipeline to one of two adjacent CDFs. Upon settling of the pumped slurry, return water would be released to the Delaware River through sluice gate structures via Whites Basin. As of 2014, Whites Basin has a total capacity of 1,825,000 cubic yards (CY), and has, historically, been pumped out every two years. The rehandling basin discharge and removal limits are set by NJDEP in the Water Quality Certificate issued for facility operation on February 14, 2014.

Informal consultation was completed in September 2014. We determined that all effects to endangered Atlantic and shortnose sturgeon would be insignificant and discountable (NMFS 2014c). Listed sea turtles and whales were determined to not be present within the Weeks Marine action area and therefore impacts to ESA-listed sea turtle and whale species were not discussed.

6.1.2.5 *Other Federally-approved Maintenance Dredging Operations*
We have completed several informal consultations on effects of in-water construction activities in the Delaware River permitted by the USACE. 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 the USACE. 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.

6.1.3 *Federally Authorized Private Projects*
Several private projects in the Delaware River have undergone informal or formal consultation. These projects involve dredging, construction (including pile driving), and vessel traffic associated with construction and operations of the new or modified facility discussed below.

6.1.3.1 *Southport Marine Terminal (CENAP-OP-R-2009-0933)*
The Southport Marine Terminal project is located at the eastern end of the Philadelphia Naval Business Center, formerly known as the Philadelphia Naval Shipyard, in the city and county of Philadelphia, Pennsylvania. The applicant proposes to construct a new marine terminal on

approximately 116 acres of currently vacant land. In a 2010 letter concerning the proposed project's DOA permit application, we determined that the proposed project would have substantial and unacceptable impact on aquatic resources of national importance. We completed an informal consultation with USACE in March 2013. In a February 21, 2013, letter that the USACE sent to us, USACE disagreed with our position that the proposed project would have substantial and unacceptable impacts on the habitat of any prey species associated with the managed species under the responsibility of us. The USACE argued that the proposed mitigation measures adequately compensated for the loss of aquatic habitat at the Southport project site that would be used by prey species. The USACE also determined that the proposed project was unlikely to adversely affect any species listed as threatened or endangered, provided the project adhered to special timing restrictions and conducted appropriate mitigation. In a letter dated March 21, 2013, we concurred with the USACE's determination that the proposed action was not likely to adversely affect any ESA listed species under our jurisdiction and that all effects to protected species were insignificant and discountable. The Section 10/404 Permit was issued by the USACE on April 16, 2013 and included a condition that mitigation be performed. This mitigation is required to compensate for losses of 9.71 acres of aquatic habitat and 3.75 acres of non-tidal wetlands. The proposed compensation/mitigation site is located in the tidal freshwater reach of the Delaware River at the confluence of Neshaminy Creek near Delaware River RKM 115-187 (RM 115-116). Mitigation will include the creation of 8.22 acres of tidal marsh, 1.67 ac of tidal mud flat, 1.6 acres of additional shallow water habitat, 3.25 acres of SAV, and creation of freshwater redbelly turtle nesting habitat. As of the date of this report, project construction has not started.

In November 2016, the Philadelphia Regional Port Authority suspended the bid process for the vacant 195-acre Southport Marine Terminal Complex (Loyd 2017). Instead of developing a new terminal facility, the Commonwealth of Pennsylvania invested $93 million into landside development at the site, including development of 155 paved acres and conversion of a former seaplane hangar into an automobile processing and detailing facility (Loyd 2017).

6.1.3.2 Paulsboro Marine Terminal (CENAP-OP-R-2007-1125)

The Paulsboro Marine Terminal (PMT) is located in Paulsboro, Gloucester County, New Jersey at RKM 144 (RM 89.5), approximately 4.8 RKM (3 RM) north of the proposed marine terminal. USACE issued a permit for the construction of the project in January 2011. The New Jersey Department of Environmental Protection issued their permit, including water quality certification and coastal zone management approval, on October 15, 2010. The PMT wharf will accommodate four berths and is expected to handle a variety of general cargo. Berths 1, 2 and 3 are designed to accommodate Handymax[15] class cargo vessels, which are typically 650 ft long and 95 ft wide. The fourth berth will be designated as a barge berth and is designed to accommodate a typical 400-ft long by 100-ft wide barge. A ship traffic modeling study was completed in September 2010 for the project. The model was used to assess the impact of the work load brought by PMT on the marine traffic in the Delaware River Main Channel. The results of the model show the expected increase in the daily number of vessels at seven locations within the Delaware River, once the Paulsboro terminal was operational. The predicted increase in daily counts at any location was consistently less than 1 and the 95% confidence interval was

15 Handymax is a commonly occurring, general purpose bulk, oceangoing cargo ship at southern New Jersey ports. Typical Handymax ships are 650 feet long and 95 feet wide.

between 0.7 and 1. Using this model, USACE predicted that the construction and operation of the PMT would, on average, result in an increase of one additional ship in the Delaware River per day. In the 2010 consultation, the USACE determined that given the high volume of traffic on the river and the variability in traffic in any given day, the increase in traffic of one cargo vessel per day is negligible and that it is unlikely there would be any detectable increase in the risk of vessel strike to shortnose sturgeon, Atlantic sturgeon or sea turtles. Listed whales were not identified to be present within the PMT action area and therefore impacts to ESA-listed whale species were not discussed. In a letter dated July 25, 2011, we concurred with the USACE's determination that all effects to these species would be insignificant and discountable (NMFS 2011).

6.1.3.3 Crown Landing Project (CENAP-OP-2005-0145)

The Crown Landing project was located in Logan Township, Gloucester County, New Jersey, at RKM 125.5 (RM 78), approximately 13 RKM (8 RM) downriver of the proposed marine terminal. On May 23, 2006, we issued a biological opinion to the Federal Energy Regulatory Commission (FERC) and USACE regarding the effects of the issuance of an Order by FERC to Crown Landing to site, construct and operate a liquid natural gas (LNG) import terminal on the banks of Delaware River and the effects of the USACE issuing two permits to Crown Landing for the construction of this facility. In the biological opinion, we concluded that the proposed Crowns Landing project may adversely affect, but is not likely to jeopardize, the continued existence of any listed species.

In the biological opinion, we examined the likely direct and indirect effects of the proposed action on the shortnose sturgeon in the Delaware River and their habitat within the context of the species current status, environmental baseline, and cumulative effects. Sea turtles and listed whales were not expected to occur in the area to be affected by the construction of the LNG facility. As such, they were not likely to be affected by the construction or dredging required to build the terminal. The biological opinion also addressed potential interactions between listed species and LNG ships. It was determined that, because shortnose sturgeon are not known to be vulnerable to ship strikes, an interaction between an LNG vessel and a shortnose sturgeon would be extremely unlikely to occur. It was also stated that, based on the best available information, sea turtles are thought to be able to avoid large LNG vessels or to be pushed out of the impact zone by propeller wash or bow wake. Consequently, the likelihood of an interaction between a sea turtle and an LNG vessel was found to be discountable. Finally, based on the implementation of the proposed ship strike reduction measures and the limited number of ship strikes that have been documented in the Delaware Bay region (13 in 30 years), the biological opinion concluded that the likelihood of an LNG tanker associated with the Crown Landing terminal colliding with a whale is likely to be insignificant (NMFS 2006).

The biological opinion also included an ITS exempting the take (lethal entrainment in cutterhead dredge) of up to three shortnose sturgeon during the initial dredging needed to create the berthing area, as well as the death of up to an additional three shortnose sturgeon over the first ten years of maintenance dredging permitted by USACE. As explained in the Effects of the Action section of the 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 Crown Landing project action area unsuitable for use as a migratory pathway for any life stage of shortnose sturgeon. In the biological opinion, we concluded that the proposed action was not likely to adversely affect listed sea turtles (NMFS 2006).

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. If the proposed project was to go forward, then consultation would need to be reinitiated since Atlantic sturgeon has been listed and Atlantic sturgeon critical habitat has been designated since completion of the previous consultation.

6.1.3.4 Sunoco Marcus Hook Mariner East project (CENAP-OP-R-2013-0067-46)

The Sunoco Marcus Hook site is located in Marcus Hook, Delaware County, Pennsylvania at RKM 127 (RM 79), approximately 12 RKM (7.5 RM) downstream of the proposed marine terminal. The USACE issued a Public Notice on August 3, 2015 for the modification of the existing Dock IA to allow for the onloading of ethane, butane, and propane to marine vessels in association with the Sunoco Partners Marketing & Terminals, L.P. - Marcus Hook Mariner East 1 project. The permit was issued on December 5, 2015. The work would include the demolition of existing marine structures and construction of a new approachway, roadway and pipeway, pile-supported concrete deck platform, gangway/crane tower, six mooring dolphins, three breasting/mooring dolphins with fenders and concrete-filled pilings, and walkway, a concrete containment sump with associated sump pipes, re-ringing of existing breasting cells with new steel sheet piling, and installation of new piping systems on top of the pier, and the installation of structural and fender piles. The stated purpose for the project is to allow for on-loading of propane, ethane and butane and to support the need to berth vessels for distribution of such materials to local, regional and international markets. No dredging would be required for this activity.

As stated in the Public Notice, a preliminary review of this application by USACE found that the proposed work may affect shortnose sturgeon and Atlantic sturgeon. No other ESA species were identified in the Mariner East action area. To attenuate noise impacts to fisheries during pile driving, the applicant would use vibratory hammer drivers where feasible and a cushion block with impact hammer drivers. Additionally, USACE proposed to include a seasonal restriction of March 15 through June 30 to further minimize impacts to shortnose sturgeon and anadromous fisheries. By communication to NMFS (August 12 through September 3, 2015), USACE determined that the project may affect, but is not likely to adversely affect, the shortnose or Atlantic sturgeon.

By letter dated October 1, 2015, NMFS determined that the effects to shortnose sturgeon and Atlantic sturgeon would be insignificant or discountable and agreed with USACE's determination that the project was not likely to adversely affect and listed species in NMFS jurisdiction (NMFS 2015a). In this letter, NMFS did not identify any ESA-listed sea turtles or whales within the Mariner East action area. In this letter, NMFS discussed the potential effects to listed species associated with habitat modification, piling driving, and vessel traffic.

The potential increased risk of vessel strike to sturgeon was considered as it relates vessel traffic associated with construction. NMFS found that, because the use of the dock would be the same as its previous use, there would not be an increase in vessel traffic (NMFS 2015a). Because no increase in vessel traffic was assumed, NMFS concluded that there would be no increased risk of vessel strike in the future.

6.1.3.5 Salem and Hope Creek Generating Stations (CENAP-OP-2006-6232)

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 (NMFS 2015).

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. NMFS 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 that Opinion, NMFS (2014) 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 Table 6-1through Table 6-4 below, this ITS exempts take (injured, killed, capture or collected) of 26 shortnose sturgeon, 500 Atlantic sturgeon, and 5 loggerhead, 1 green, and 2 Kemp's ridley sea turtles 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. NMFS did not identify any ESA-listed whale species within the Salem and HCGS action area (NMFS 2015).

Table 6-1. Salem and HCGS - 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)

Table 6-2. Salem and HCGS - Impingement or Collection of Atlantic Sturgeon at the Trash Bars.

Age Class and DPS	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 Subadult or adult SA DPS Subadult or adult GOM DPS Subadult or adult Carolina DPS	1 dead or alive from either the CB, SA, GOM and/or Carolina DPS	1 dead or alive from either the CB, SA, GOM and/or Carolina DPS	Total of 2 from the CB, SA, GOM and/or Carolina DPS

Table 6-3. Salem and HCGS - 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)

Table 6-4. Salem and HCGS - Impingement/Collection of Sea Turtles at the Trash Bars.

Sea Turtle Species	Salem Unit 1	Salem Unit 2
Loggerhead	4 (1 dead)	5 (1 dead)
Green	One at Unit 1 or Unit 2 (alive or dead)	
Kemp's Ridley	2 (1 dead)	2 (dead)

6.1.3.6 Emergency Clean-Up Actions associated with the M/V Athos 1 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.

6.1.4 *Ballast Operations of Federal Vessels*

Ballasting operations of Federal vessel in the action area poses potential adverse effects to protected species. We (NMFS's Office of Protected Resources, Silver Spring, MD) have completed a consultation with EPA on the Vessel General Permit (NMFS 2012a) and USCG on ballast water regulations (NMFS 2012b). In biological opinions issued June 20, 2012 (USGS) and November 28, 2012 (USEPA), we determined that the ballasting activities covered are not likely to jeopardize the continued existence of any listed species.

6.2 Fisheries

Commercial exploitation of sturgeon began in colonial times and peaked in the late 19th century (SSSRT 2010). As a result of high demand for caviar, sturgeon populations crashed by the beginning of the 20th century. Estimated annual harvest ranged from a high of 7,000,000 pounds in 1890 to just 22,000 pounds in 1920 (SSSRT 2010). No landings were reported after 1993, however, and the direct fishery was officially closed on April 1, 1998 (ASSRT 2007). Atlantic sturgeon and shortnose sturgeon are still caught as bycatch of commercial fisheries operation in the Delaware Bay gill net fishery, posing a moderate risk to this subpopulation's viability.

Recreational shad fishing is currently allowed within the Delaware River with hook and line only; commercial fishing for shad occurs with gill nets, but only in Delaware Bay. In 2012, only one commercial fishing license was granted for shad in New Jersey. Shortnose sturgeon 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 sturgeon and Atlantic sturgeon are likely less than they were in the past (NMFS 2014b).

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. The majority of these landings occur in March and April, but bycatch mortality during this period is typically low (C. Shirey, DNREC, pers. comm., 2005 as cited in ASSRT 2007).

In New England and Mid-Atlantic coastal waters (i.e. outside the action area), bycatch remains an important threat to Atlantic sturgeon, particularly in rivers or estuaries that only support a small subpopulation (<300 spawning adults per year). Modelled estimates of bycatch reported by the Northeast Fisheries Science Center range from 2,752 (2002) to 7,904 (2006) with a mean of 5,143 sturgeon (ASMFC 2007). Estimated mortality during that period was 13.8%, ranging from 352 to 1,286 dead sturgeon per year. Using an alternate model, Stein *et al*. (2004) predicted 1,385 sturgeon deaths per year as a result of bycatch. Findings of these models suggests that current level of bycatch is most likely retarding or curtailing recovery of Atlantic sturgeon, particularly for smaller populations of sturgeon, such as the Delaware River population (ASMFC

2007). The study notes that model results are likely under-estimated because not all sources of mortality are included in the NMFS observer estimate.

Reported mortality rates of sturgeon (Atlantic and shortnose) captured in inshore and riverine fisheries range from 8% to 20% (Bahn *et al*. 2012; Collins *et al*. 1996). An estimated 1,385 individual Atlantic sturgeon were killed annually from 1989 to 2000 as a result of bycatch in offshore gill net fisheries operating from Maine through North Carolina (Stein *et al*. 2004). From 2001to 2006 an estimated 649 Atlantic sturgeon were killed annually in offshore gill net and otter trawl fisheries. From 2006 to 2010 an estimated 391 Atlantic sturgeon were killed (out of 3,118 captured) annually in Northeast Federal fisheries (Miller and Shepherd 2011). Estimated rates of Atlantic sturgeon caught as bycatch in Federal fisheries are highly variable and somewhat imprecise.

Various fishing methods used in state fisheries, including trawling, pot fisheries, fly nets, and gillnets incidentally take listed species of sea turtles, but information on these fisheries is sparse (NMFS SEFSC 2001). Although past and current effects of these fisheries on listed species is not quantifiable, NMFS believes that ongoing state fishing activities may be responsible for seasonally high levels of observed stranding of sea turtles on both the Atlantic and Gulf of Mexico coasts. Most of the state data are based on extremely low observer coverage or sea turtles were not part of data collection. Therefore, these data provide insight into gear interactions that could occur, but are not indicative of the magnitude of the overall problem. Certain gear types may have high levels of sea turtle takes, but very low rates of serious injury or mortality. For example, the hook and line takes rarely result in death, but trawls and gillnets frequently do. Leatherbacks seem to be susceptible to a more restricted list of fisheries, while the hard shelled turtles, particularly loggerheads, seem to appear in data on almost all of the state fisheries. Nearshore and inshore gillnet fisheries of the mid-Atlantic operating in Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and North Carolina state waters and/or Federal waters and the bottom trawl horseshoe crab fishery in Delaware are of particular concern (NMFS 2016b).

6.3 Other Impacts of Human Activities in the Action Area

Other anthropogenic stressors in the action area include water and sediment quality and private and commercial actions. These stressors are detailed below.

6.3.1 *Contaminants and Water Quality*

Water quality in riverine and estuarine systems is affected by human activities conducted in the riparian zone, as well as those conducted more remotely in the upland portion of the watershed. Large portions of the Delaware River are bordered by highly industrialized waterfront development, including the largest freshwater port complex in the world (Delaware River Port Complex), as well as the nation’s third largest petrochemical port and five of the largest U.S. east coast refineries (DRBC 2016). This development contributes to temperature variations, and releases of metals, dioxins, dissolved solids, phenols and hydrocarbons, any of which may be acutely or chronically toxic to fish, depending on dose. Industrial development, especially the presence of refineries, has resulted in storage and leakage of hazardous material into the Delaware River. A total of 13 Superfund sites are located in Marcus Hook; an additional hazardous waste site has not been designated as a Superfund site (NMFS 2015).

Because high levels of PCBs have resulted in state-issued fish consumption advisories for certain species caught in the Delaware Estuary, these waters were and continue to be listed as impaired, requiring the establishment of a PCB total maximum daily load (TMDL). A TMDL expresses the maximum amount of a pollutant that a water body can receive and still attain water quality standards (DRBC 2017).

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

Through the early 1970s, DO concentrations in the river between Wilmington and Philadelphia regularly dropped below levels that could support aquatic life from late spring through early fall. Since 1990, DO concentrations have remained above minimum state standards throughout the entire year (R. Greene, DNREC, pers. comm. 1998, as cited in ASSRT 2007). Despite improvements in Delaware River water quality over the last two decades, Moberg and DeLucia (2016) reported that minimum daily DO concentrations were above 5.0 mg/L in 90% of the observations during years when sturgeon recruitment was observed. The median minimum daily DO concentration during such years exceeded 6.0 mg/L during the spawning and egg and larval development periods. During years when recruitment was not observed, median minimum daily DO concentrations was between 4.0 and 5.0 mg/L, and conditions were frequently less than 4.0 mg/L. Low DO concentration also corresponded to period of increased water temperature and decreased flow in the river. Factors impacting flow, temperature, and DO concentrations include upstream reservoir operation, water withdrawals, and climate variability.

Contaminants such as metals, PAHs, pesticides, and PCBs can adversely affect aquatic life, including sturgeon. Endocrine disrupting chemicals (EDCs), including PCDDs/TCDFs, DDE, PCBs and cadmium, have been detected in tissue of shortnose sturgeon caught in the Delaware River and are linked to reproductive and developmental disorders in other species (SSSRT 2010). Early life stages of sturgeon may be particularly sensitive to high concentrations of contaminants (Chambers et. al. 2012). No targeted studies of chemical contamination in shortnose sturgeon have been conducted, but it is likely that industrialization in rivers may adversely impact the species (NMFS 2015). The SSSRT ranked poor water quality as a moderately high risk for shortnose sturgeon in the Delaware River (SSSRT 2010).

Riverfront development has the potential to alter the connectivity between the river and the adjacent floodplain and to disrupt natural processes, such as sediment and nutrient transfer (Noe and Hupp 2005 – got pdf, add to EndNote). Due to historical development and industrial use, much of the lower Delaware River is disconnected from the floodplain by berms and raised shorelines.

The states of New Jersey, Delaware and the Commonwealth of Pennsylvania have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of chemicals in the action area. Permittees include municipalities for wastewater treatment plants and other industrial users. The states will continue to authorize discharge of waters through State Pollution Discharge Elimination System (SPDES) permits.

6.3.2 *Sediment Quality*

6.3.2.1 Wharf Area Investigation

On behalf of the previous site owner (Chemours), AECOM (2016) investigated sediment contamination near the existing wharf (i.e. the wharf area, which is the nearshore portion of the dredging area). This investigation was completed in accordance with AECOM's Wharf and Outfall Investigation Work Plan (Work Plan), submitted to the NJDEP on February 12, 2016. Ten sediment cores were collected within the Wharf Area. Samples were collected from each core and analyzed for extractable petroleum hydrocarbons (EPH), PAHs, aniline, diphenylamine, nitrobenzene, metals, Total Organic Carbon (TOC), grain-size distribution, oxidation reduction potential and pH. Sediment chemistry results were compared to New Jersey Ecological Screening Criteria (ESCs) and background sediment concentrations to determine whether there was indication of potential historical releases within the Wharf Area. A total of 10 background samples were collected from upstream and downstream locations near the site's property boundary. The investigation concluded that there has been limited, if any, release of organic compounds in the Wharf Area sediments, and that those sediments do not warrant further evaluation. Comparisons to the background dataset, collected as a part of this evaluation, also indicate that concentrations of organic and inorganic constituents, as a whole, are consistent with background conditions in the Delaware River. Results of the investigation are summarized below.

Overall, organic constituents (EPH, PAHs, aniline, diphenylamine, and nitrobenzene) were detected in a limited number of wharf area sediments (AECOM 2016). Sediment EPH ranged from non-detect to 777 mg/kg. Free or residual petroleum product was not present in sediment at concentrations less than 17,000 mg/kg and therefore, AECOM (2016) reported that significant release was unlikely to have occurred regarding petroleum products. Total PAHs concentrations exceeded applicable NJDEP Ecological Screening Criteria (ESCs) in most of the samples, including in the background samples (AECOM 2016). Further comparison indicated that concentrations of PAHs in the nearshore sediment samples are lower than the background 95% Upper Tolerance Limits (UTL). AECOM (2016) therefore concluded that PAHs concentrations in nearshore sediments likely reflect the anthropogenic background sources and not site-related releases.

Metals were generally detected above the ESCs in both the Wharf Area and background sediment samples (AECOM 2016). Metals that were detected above applicable ESCs at one or more location include arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, and zinc. Results indicate that the maximum concentrations of metals observed in nearshore sediment are generally lower or similar to the background UTLs and therefore are generally representative of background conditions (AECOM 2016). Further, detected metal concentrations showing higher variability may reflect an association with TOC. Metals generally have high affinity to bind to TOC and hence are relatively enriched in substrates with higher TOC (Di Toro *et al*. 2005; Thakali *et al*. 2006 as cited in AECOM 2016). Statistical analyses indicate that as a whole, concentrations of metals in sediment are not statistically different ($p<0.05$) between the Wharf Area and the background samples (AECOM 2016).

6.3.2.2 Dredging Area Investigation

On behalf of the Applicant, Ramboll Environ characterized sediments in the Dredged Area to determine disposal methods for the material proposed to be dredged as part of the Action (see

Section 2.0). This work was conducted in accordance with a Sediment Sampling and Analysis Plan, approved by NJDEP on April 21, 2016 (Appendix B). The results of this characterization were provided to the USACE in August 2016 (Ramboll Environ 2016). A summary of these results were also provided in the Dredged Material Management Plan (Ramboll Environ 2017, see Appendix A) prepared by the Applicant and submitted to the USACE. In April 2016, a total of 52 cores were collected in the dredging area. A total of 224 samples were submitted to the laboratory for analysis. These samples included: (a) 56 individual samples from discrete sediment strata (i.e., sand or silt) within cores (referred to as individual core samples) (b) 9 multi-core composite samples, which were individual core samples composited from multiple cores, (c) 149 discrete samples, which were collected from the fine-grained material to vertically delineate specific constituents at a core location, and (d) 10 composite samples subjected to Synthetic Precipitation Leaching Procedure (SPLP) and analyzed for metals, pesticides, semi-volatiles, cyanide, and PCB congeners. Individual core samples and multi-core composites were analyzed for metals, pesticides, semi-volatiles, cyanide, and PCB Aroclors, total organic content, percent moisture content, and grain size distribution. Select discrete samples were analyzed for PAHs, arsenic, vanadium and or PCBs depending on the core location.

In summary, sampling within the dredging area indicates that the fine-grained sediments are impacted by PAHs, certain metals (primarily arsenic) and PCB aroclors at concentrations exceeding NJRDSRS. Constituent concentrations in the dredging area were also screened against New Jersey's Freshwater ESCs. Arsenic exceeded the Freshwater Severe Effects Level (FWSEL) at 4 out of 43 individual core locations. Chromium (total) was detected above FWSEL criteria in 2 out of 38 cores. In addition, copper was observed above FWSEL criteria at a single core location. No other constituents exceeded the FWSEL criteria.

6.3.3 *Vessel Activity*

Vessels striking sturgeon have been reported from several rivers, estuaries, and bays. Published studies in scientific journals, state sturgeon reporting programs, the NMFS salvage program, and reports, personal communications, and news articles all provide information and data on sturgeon vessel interactions. The following section describes vessel activity in the Delaware River and the Federal Navigation Channel and summarizes the best available information on the risk of vessel strike on shortnose and Atlantic sturgeon.

6.3.3.1 Vessel Activity within the Project Area

The project area includes the area between the marine terminal's berth and the Federal navigation channel. This area was formerly operated as part of a long-standing industrial facility that had two active berths. However, the existing berths have not been used since the early 1990s. One berth served barges and the other berth served larger vessels (tankers). Prior to the cessation of operations in the early 1990s, the facility received one barge and one tanker per month, a rate equivalent to 24 vessels or 48 round-trip vessel trips per year. Currently the berths are not in use.

6.3.3.2 Vessel Activity within the Action Area

Private and commercial vessels, including fishing vessels, operating in the action area have the potential to interact with listed species. Private cargo vessels and numerous smaller commercial and recreational vessels transit the Delaware River. Fishing vessels, recreational vessels, and other types of commercial vessels may affect listed species through disturbance or injury/mortality due to collisions, chemical releases, increased human interactions, and entanglement in anchor lines.

The Delaware River is geographically and operationally one of the most significant waterways on the East Coast of the U.S. for port operations. Collectively, the Ports of Philadelphia, South Jersey and Wilmington, DE are one of the largest general cargo port complexes in the nation (Altiok *et al.* 2012).

The USACE publishes data on waterborne traffic movements involving the transport of goods on navigable waters of the U.S. (http://www.navigationdatacenter.us/wcsc/wcsc.htm). These data include dry cargo, tankers, and towboats. Number of vessels trips in the Navigation Channel from Philadelphia to sea have varied during the period from 2005 through 2015 (Table 6-5). Total number of vessels, number of vessels with 30-foot draft or deeper, and number of self-propelled vessels decreased in 2008 after the economic recession and then increased during the last three years (Table 6-5). We use the median yearly trips for the period from 2005 to 2015 to calculate baseline activity as vessel activity varies, there is no obvious trend, and the period includes the peak of 2005. Median number of (up- and downbound) vessel trips from 2005 through 2015 was 42,398 (min=32,448; max=111,911) when all vessels types and drafts are included. However, self-propelled vessels and vessels with deep draft may be more likely to injure or kill sturgeon. Including only self-propelled vessels, the median number of (up- and downbound) trips is 32,004 (min=23,620; max=98,079). Including only vessels with a 30-foot draft or deeper (of all vessel types), a median of 2,164 vessel trips were made per year (min=1,982; max=2,774). Figure 6-1. Number of vessel trips of different categories of vessels on the Delaware River navigation channel from Philadelphia to Sea from 2001 to 2015. shows number of vessel trips per year of different vessel types.

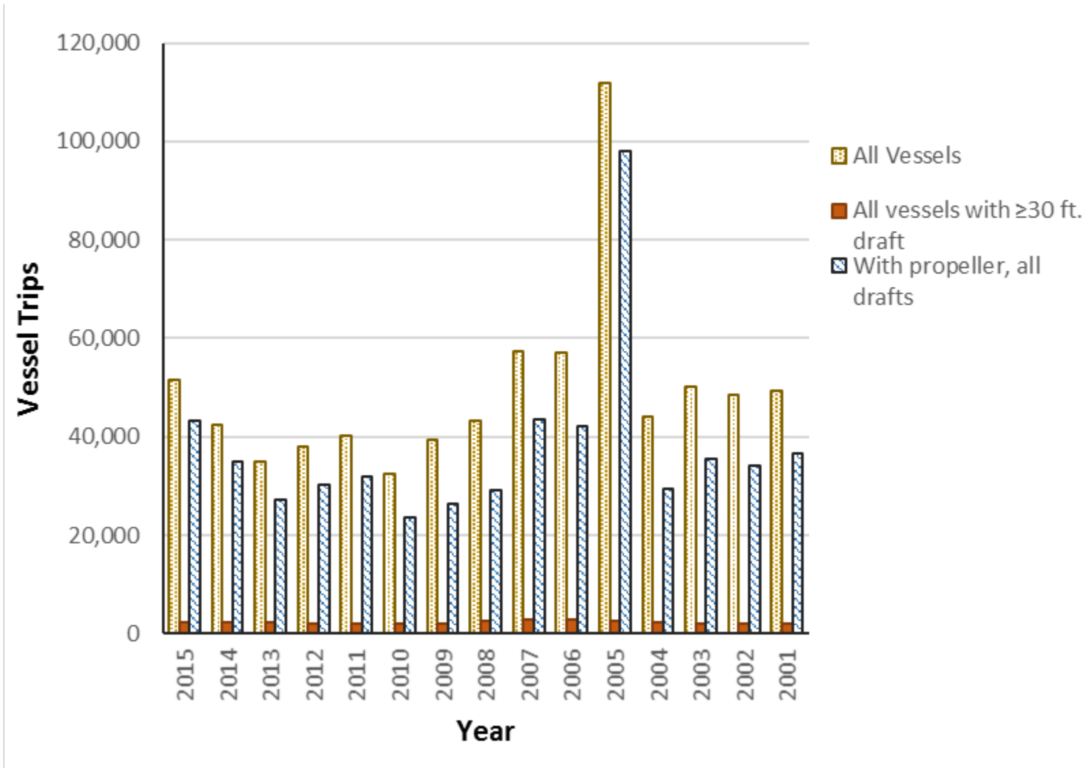

Figure 6-1. Number of vessel trips of different categories of vessels on the Delaware River navigation channel from Philadelphia to Sea from 2001 to 2015.

This numbers 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 vessels 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 expected to be seasonal with peak traffic occurring between the Memorial Day and Labor Day holidays (USCG 2012 as cited in NMFS 2017e).

Table 6-5. Vessel activity on the Delaware River from Philadelphia, PA, to sea as number of trips [Total Transits by Year].

Trip Direction	2005	2006	2007	2008	2009	2010
Upbound	55,815	31,501	31,579	21,588	19,738	16,237
Downbound	56,096	25,691	25,843	21,549	19,603	16,211
Total	111,911	57,192	57,422	43,137	39,341	32,448

Trip Direction	2010	2011	2012	2013	2014	2015
Upbound	16,237	20,008	18,945	17,461	21,129	25,766
Downbound	16,211	20,077	19,016	17,532	21,269	25,808
Total	32,448	40,085	37,961	34,993	42,398	51,574

Vessel traffic in the Delaware River is primarily driven by economic growth and it is not possible to accurately project future vessel traffic. The Delaware River port system has observed steady growth in vessel arrivals associated with increased economic activity over the last several years. The USACE provided in the biological assessment information that the number of cargo vessels per year using the Delaware River is expected to increase in the absence of any new port facilities (Alitok *et al*. 2012, USACE 2017a). The annual percentage increase in vessel arrival rates is estimated between 1.0% and 2.5% for general and container cargo types in the years 2010 to 2020 (Alitok *et al*. 2012). The annual number of containership, bulk, and general cargo vessels will increase by 75% from 1,162 (baseline 2004 through 2008) to 2,037 in 2038, based on a 30-year vessel traffic simulation by Alitok *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.

To project future vessel activity during the lifetime of the proposed project, we used the projected growth rate for general and container type vessels in the Delaware River in the Biological Assessment of 1.5 to 2.5 percent growth over the next 30 years. Using the average of 1.75 percent growth of dry cargo and assuming that tankers and towboats will remain at baseline level, we project that total number of vessel trips will gradually increase to 54,608 vessel trips in 2047. Baseline for different vessel types was calculated as the median yearly vessel trips during the period from 2005 through 2015 using the waterborne commerce data provide by the USACE on their website. Median number of vessel trips per year during the period was 21,801 for cargo vessels, 9,313 trips for tanker vessels, and 7,406 towboat trips with a total median of 42,398 vessel trips per year for all vessel types. That tankers will remain the same is based on the assertion in the USACE's biological assessment that tanker activity is based on the capacity of refineries. Refinery capacity is finite and will not increase unless exiting refineries expand or new refineries are built.

6.3.3.3 Information on Sturgeon Mortality Resulting from Vessel Strike

Brown and Murphy (2010) reported on 28 Atlantic sturgeon carcasses found in the Delaware River and Bay between 2005 and 2008 of which 14 mortalities were identifies as the result of vessel strike. The remaining fish where too decomposed to determine cause of death but the authors believed that the majority most likely died after interaction with vessels. Of the mortalities reported, 39% were juveniles. The majority (71%) of sturgeon carcasses showed sign of interaction with large commercial vessels with large propellers and deep draft (Balazik *et al.* 2012b, Brown and Murphy 2010). This corresponds to conclusions drawn from other rivers (Balazik *et al.* 2012b). Vessel strikes are thought to predominantly occur between May through July and likely affect adults migrating through the river to spawning grounds (Brown and Murphy 2010).

The Delaware Division of Fish and Wildlife started in 2005 a reporting program where the public can report sturgeon carcasses they find in the Delaware River and Bay (http://apps.dnrec.state.de.us/Sturgeon/Home/Why). The data does not represent a scientific or dedicated survey. All of the sturgeon mortalities were reported by interested citizens or directly by agency biologists who encountered the carcasses while conducting surveys on other species (personal communication, Ian Park, DENRC, 2017). Thus, while it represents the best available data, it cannot be used to compare mortality rates between years. A lack of a population index for the Delaware River further makes it impossible to evaluate number of reported carcasses relative to, for instance, yearly differences in vessel activity. Over the period from 2005 through 2016[16], the public and state employees reported 195 sturgeon carcasses (personal communication, Ian Park, DENRC, 2017). Of these, 182 were identifies as Atlantic sturgeon, 11 were identified as shortnose sturgeon, and two were not identified to species.

Of all sturgeon carcasses reported, 107 showed sign of interaction with boat propeller and 13 were identified as having died by other causes (these are included in discussions of mortalities caused by other stressors than vessel strike). Cause of death could not be determined for 75 of the carcasses either because they were too decomposed when examined by state biologists or proper pictures were not provided (for carcasses not physically examined by state biologist) to identify injuries. However, many of the decomposed carcasses missed head or consisted of only part of the body suggesting that a large propeller mutilated them.

Atlantic sturgeon

Vessel strike was identified as the likely cause of death for 99 or the 182 carcasses identified as Atlantic sturgeon over the period from 2005 through 2016. Of the 182, 20 were observed outside the Delaware River and Bay and are excluded in the calculations below. Over the 12-year period, number of Atlantic sturgeon vessel mortalities in Delaware River and Bay ranged from 2 to 15 (median = 5.5) per year. If the carcasses which cause of death were undetermined are included, then the total number of reported carcasses was 149 with a range from 6 to 19 (median = 11.5) per year. Seventy one percent (71 %) of the Atlantic sturgeon vessel mortalities occurred during May through July corresponding with spawning migration.

Of the 149 Atlantic sturgeon whose cause of death were reported either as vessel strikes or unknown, 78 (52.4 %) were adults, 29 (19.5%) were juveniles, and 42 (28.2%) had no reported life stage. Including only those reported as vessel mortalities, a slightly higher proportion (70%) during May through July were adults than during the other months of the year (54.2%) while the difference was reversed for juveniles (8.3% vs. 33.3%). However, changes in percent carcasses that have no reported life stage (21.7% vs. 12.5%) confound any firm conclusion on the differences. Still, this corresponds to findings by others that most Atlantic sturgeon mortalities are adults and that they are at risk of vessel strike in spring when they move into the river (Balazik *et al.* 2012b, Brown and Murphy 2010, Fisher 2011).

Recent public outreach and social media campaigns have improved public reporting of sturgeon carcasses since 2012 (DNREC 2016), and 2016 is the most recent full year of data available. These data represent the best available information in calculating sturgeon mortalities per vessel trip. During this time period, 78 Atlantic sturgeon were reported. Of the dead Atlantic sturgeon reported, 43 (47.3%) died from apparent vessel strikes and 13 (14.3%) died from apparent non-

[16] The data provided are the same as used by Brown and Murphy (2010) for the years 2005 through 2008. However, the data provided us by DENRC includes an additional six reports of Atlantic sturgeon carcasses not included in Table 1 in Brown and Murphy (2010).

vessel related injuries. A cause of death could not be determined for the remaining 35 (38.5%) carcasses. For purposes of this Opinion, it is conservatively assumed that those mortalities were due to vessel strikes. Accordingly, over the 4-year period (2012 through 2016), there were a median of 16 vessel strike mortalities of Atlantic sturgeon in the Delaware River per year.

Since not all mortalities are observed or reported, it is likely that the actual number of sturgeon mortalities is greater than the 16 per year. A study is currently being conducted in the Delaware River by researchers at Delaware State University in partnership with the US Fish and Wildlife Service and DNREC to estimate the percent of sturgeon mortalities that are observed and reported. Data from this study were not available at the time of this biological opinion. A study of sturgeon carcasses observations on the James River (Virginia) by (Balazik *et al.* 2012b) found that monitoring in the James River documented less than one-third of all vessel strike mortalities. Although monitoring efforts in the James River cannot be compared directly to those in the Delaware River, this study provides a best available information to make a reasonable estimate of the number of observed carcasses relative to total vessel strike mortalities. For purposes of this Opinion, we assume that the average number of reported vessel strikes in any given year represents one-third of actual mortalities. This assumption may overestimate the total number of sturgeon struck and killed per year and is therefore conservative. We estimate the median number of Atlantic sturgeon vessel strike mortalities (juvenile and adult) within the Delaware River during the 2012 to 2015 period to be three-fold higher than 16, or 48 per year.

The waterborne commerce data does not include recreational and fishing boats and is therefore an underestimate of all vessel traffic within the action area. However, by using the data on total commercial vessel activity, we also include vessels that are not self-propelled and vessels of all drafts (see http://www.navigationdatacenter.us/wcsc/wcsc.htm). Since, most or all vessel caused injuries and mortalities is likely related to interaction with vessel propellers, and deeper draft vessels may pose more of a risk than shallow draft vessels, the data represents an overestimate of the threat posed to sturgeon (i.e., overestimate the probability that a sturgeon will be killed by a commercial vessel). While it is not possible to predict exactly how these two factors – underestimate of total vessel traffic and overestimate of threat from commercial vessels – will affect overall risk of vessel strike, we assume the two factors outweigh each other.

Given this scenario, we estimate that number of sturgeon killed by vessel trip by dividing the estimated median number of Atlantic sturgeon vessel mortalities (48) on median number of vessel trips (42,398). Thus, each vessel trip killed 0.00113 sturgeon. Put another way, one sturgeon is killed for approximately every 883 vessel trips.

To project future mortality of sturgeon by vessel interaction to the end of the lifetime of the proposed project; we multiplied number killed per vessel trip (0.00113 sturgeon) by projected future vessel (up- and downbound) trips. In 2047, number of vessel trips in the Delaware River and Bay will have increased with 16,088 to a total of 54,608 vessel trips assuming a 1.75% yearly growth rate. Thus, estimated number of sturgeon killed by vessels will gradually increase from a current baseline of 48 to 62 in 2047.

However, existing information on the abundance and distribution of Atlantic sturgeon and shortnose sturgeon in the Delaware River is limited. As a result, there is insufficient data to quantitatively evaluate how any future changes in sturgeon population size, sex ratios, and or spatial or temporal distributions may affect the annual estimated number of sturgeon vessel strike mortalities in a given year. Recognizing that there is uncertainty of the risk of vessel strikes with sturgeon, the estimated number of sturgeon vessel strike mortalities in this Opinion is based on best available information using current data and relies on several conservative assumptions.

Shortnose sturgeon

Records of shortnose sturgeon vessel strikes in the Delaware River are considerably lower than for Atlantic sturgeon. Of the 11 shovelnose sturgeon included in the DENRC data, eight were reported as likely vessel mortalities and three had no cause of death reported. Numbers ranged from zero to two shortnose sturgeon per year over the ten-year period. Of the 11 shortnose sturgeon, two (18.2%) were adults, 3 (27.3%) were juveniles, and life stage was not reported for six (54.6%) of the carcasses.

Other potential vessel strike of shortnose sturgeon incudes one incident in 2007 and one in 2008. On June 8, 2008, a shortnose sturgeon was collected near Philadelphia. The fish was necropsied and found to have suffered from blunt force trauma. Though the injury was considered caused by interaction with a vessel, it is no way to confirm this. On November 28, 2007, a shortnose sturgeon was collected on the trash racks of the Salem Nuclear Generating Facility. Although the fish was not necropsied, a pattern of lacerations on the carcass suggested possible vessel interaction. It is unknown if those lacerations were caused pre- or post-mortem.

The low number of shortnose sturgeon carcasses reported from the Delaware River basin may be related to a low number of large fish present in areas with high vessel activity, that the smaller shortnose sturgeon is less often observed and reported, a combination of these two factors, or other unknown factors. The data therefore provides little information to evaluate the risk of vessel strike to shortnose sturgeon and the consequence of projected increased vessel traffic in the Federal Navigation Channel. It is reasonable to assume that an increase in vessel traffic will increase the risk of shortnose sturgeon interacting with vessels. However, we cannot predict the extent at which this will result in an increase in vessel related mortalities.

6.3.3.4 Impacts to River Bottom Substrate from Vessel Activity

The largest commercial vessels (*e.g.*, oil tankers, container ships, etc.) pass throughout the navigation channel on a daily basis. 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 some large, deep draft vessels (*e.g.*, trash vessels) use the extent of the 40-foot channel to Trenton. 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 throughout the navigation channel from Trenton to the sea, with increased levels of turbidity and total suspended sediments. 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 may take up as much as approximately 150 feet of the channel, likely causing sediment disturbance throughout the channel and beyond.

6.4 Summary of Available Information on Listed Species in the Action Area

6.4.1 *Shortnose Sturgeon in the Action Area*

6.4.1.1 Biology

Shortnose sturgeon appear to be strictly benthic feeders (Dadswell 1984). Adults eat mollusks, insects, crustaceans and small fish. Juveniles eat crustaceans and insects. The Asiatic river clam (*Corbicula manilensis*) is a major component of the benthos in the tidal Delaware River; it has have been documented in the diet of shortnose sturgeon in the Delaware River and other estuaries (Brundage, pers. comm. 2011). The invasive clam 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.

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. In May 2005, the scientists with the Environmental Research Center initiated a one-year survey for juvenile sturgeon in the Delaware River in the vicinity of the proposed Crown Landing LNG project (ERC 2005). 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. 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 Crown Landing LNG 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. 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).

6.4.1.2 Overall Distribution in the Delaware River and Action Area

Shortnose sturgeon occur in the Delaware River from the lower bay upstream to at least Lambertville, New Jersey (RKM 238). Tagging studies by O'Herron *et al.* (1993) found that the most heavily used portion of the river appears to be between RKM 190 below Burlington Island and RKM 220 at the Trenton Rapids.

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. 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.

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). 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.

The discussion below will summarize the likely seasonal distribution in different reaches of the Delaware River of each shortnose sturgeon life stage. Based on the best available information, eggs and larvae are not likely to be in the action area. Due to the benthic, adhesive nature of the eggs, they only occur in the immediate vicinity of the spawning area. Yolk-sac larvae are also limited to an area close to the spawning grounds, and therefore, not likely to occur in the action area. Distribution of adult and juvenile shortnose sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity.

Spawning

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. In the Delaware River, movement to the spawning grounds occurs in early spring, typically in late March[17], with spawning occurring through early May, and sturgeon typically leaving the spawning grounds by the end of May.

Spawning areas is well upstream of the action area. Studies conducted between 2007 and 2013 (ERC 2008; DNREC 2015) indicate that shortnose sturgeon utilize at least a 22 km reach of the non-tidal river from Trenton rapids (about RKM 214, RM 133) 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 (RKM 238, RM 148) and at the Scudders Falls (RKM

[17] 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.

223.7, RM 139). 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 2007) (ERC 2009). 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.

During the spawning period, males remain on the spawning grounds for approximately a week while females only stay for a few days (O'Herron *et al.* 1993). Spawning 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).

Eggs, larvae

Shortnose sturgeon eggs adhere to the substrate in the spawning area quickly after being deposited and will, therefore, remain in the spawning area. Incubation time depends on water temperature. Eggs from Delaware River shortnose sturgeon incubated at water temperatures ranging between 8° and 12° C hatched after 13 days (Meehan 1910) while eggs from Connecticut River shortnose sturgeon hatched after 8 days at 17° C water temperature (Buckley and Kynard 1981).

No studies have been conducted on Delaware River shortnose sturgeon larvae and it is difficult to determine their distribution within the river. Studies of shortnose sturgeon in other rivers have generally found the yolk sac larva (also called free embryo) phase lasting approximately 8-12 days, during which they seek cover in-between coarse bottom substrate, and remain near the spawning site (Buckley and Kynard 1981, Kynard and Horgan 2002, Parker 2007, Richmond and Kynard 1995). However, some swim up and drift behavior may occur immediately following hatching if the yolk sack larvae cannot find suitable cover or to initiate some dispersal and dispersion (Kynard and Horgan 2002). In either case, yolk sack larvae would distribute and remain at or near the spawning areas above Trenton.

We have very little information about shortnose sturgeon post yolk sac larvae and YOY distribution in the Delaware River. Larvae from Connecticut River emerge from cover, start feeding (exogenous feeding), and seem to drift for a short period of two to three days following emergence from cover (Kynard and Horgan 2002). After this initial drift they seek towards the bottom, become demersal, and, therefore, likely residential within the reach. Buckley and Kynard (1981) and Kynard and Horgan (2002) suggested that shortnose 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. However, (Parker 2007) observed that shortnose sturgeon in the Savannah River, South Carolina, had a longer dispersal with multiple, prolonged peaks and fish continued a low level of downstream movement for the whole larval period and as early juveniles.

Kynard and Horgan (2002) estimated that post yolk sac larvae in the Connecticut River move approximately 7.5km/day during this initial 2 to 3 day migration. If this holds true for Delaware River also, though we recognize that flow and current velocities differ between rivers, then PYSL could distribute downstream to about Burlington Island, at approximately RKM 191, to Beverly, NJ, at approximately RKM 185. However, we expect YOY to nurse above salt front which is median monthly location range between RKM 108 and 122 which includes the Marcus Hook range.

If Delaware River Shortnose sturgeon larvae and juveniles continue downstream migration (1-step migration) to juvenile nursing areas, then the larvae and YOY would need to distribute for approximately another 84 to 108 km. Some information indicate that this may be true. Blasting or rock formations at Marcus Hook and Tinicum Ranges for the deepening of the Federal Navigation Channel requires relocation trawls of sturgeon before blasting occurs. The relocation trawls collected at least two YOY at the Marcus Hood Range based on their length, one in late December and one in late January (ERC 2017). However, we do not know whether these moved in one long migration or if YOY move downstream in fall after remaining in upper reaches through summer.

Juveniles

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 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. In the Delaware River, the salt front location varies throughout the year, with the median monthly salt front ranging from RKM 107.8 to RKM 122.3 (Delaware River Basin Commission 2017). The maximum recorded upstream occurred during the drought of 1960 with the salt front extending as far north as to Philadelphia, Pennsylvania (RKM 164, RM 102) and may retract as far south as Artificial Island at RKM 87 (RM 54).

The Crown Landing sampling from April through August 2005 reference above collected three juvenile shortnose sturgeon during the June, July and August, one fish in each of the sampling events (ERC 2005). Two of the shortnose sturgeon were collected at RKM 126 and one 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. Thus, as evidenced by the Crown Landing study, juvenile shortnose sturgeon have been documented between RKM 130-119 from June – November.

Two juvenile shortnose sturgeon with acoustic transmitter tags were detected moving in the reach below the proposed marine terminal site in November and early December for then to be last detected upstream at RKM 135 and 190, respectively, in December (ERC 2012). This suggest that at least some juveniles move into the upper tidal reaches in winter. However, O'Herron believes that if juveniles are present below Philadelphia, Pennsylvania, they would likely aggregate closer to the downstream boundary in the winter when freshwater input is normally greater (O'Herron 2000, pers. comm.). This is supported by acoustic tracking of tagged juveniles that indicates that juveniles are likely overwintering in the lower Delaware River from Philadelphia to below Artificial Island (ERC 2007).

Brundage and O'Herron (2014) carried out a relocation trawl pilot study in the Marcus Hook Anchorage (RKM 127-139) from January 25-March 7, 2014. While trawling, they collected 67 shortnose sturgeon of which 19 were juveniles, indicating that the Marcus Hook area is used by juvenile shortnose sturgeon.

Similarly, the USACE is currently conducting blasting of rock outcrops in an effort to deepen the Federal Navigation Channel from 40 feet to 45 feet. As part of these activities, they are required to conduct relocation trawling of sturgeon before setting off charges. Two relocation trawling and blasting seasons occurred from November 15 – March 15 during the winter of 2015-2016 and 2016-2017. During the 2015-2016 season, 111 shortnose sturgeon were captured in the general blasting area (~RKM 108-136.8) (ERC 2016). In the second season (2016-2017), 300 shortnose sturgeon were captured in the general blasting area (RKM 190-199)(ERC 2017). In the 2016-207 end of season report, ERC (2017) presents a length-frequency distribution for captured shortnose sturgeon showing that 77% were adults. These data further demonstrate the use of the action area by adult shortnose sturgeon throughout the winter months (see Figure 3-1 below).

The results from the relocation trawl pilot study carried out in 2014 and subsequent relocation trawling efforts in 2015-2017, indicate that juvenile shortnose sturgeon are present in the Marcus Hook area during the winter in larger numbers than previously predicted. Tagged shortnose sturgeon were also detected in the Marcus Hook area during a sound deterrent test carried out from March 21 – May 7. Further, the results of tracking studies indicate that during the winter months juvenile shortnose sturgeon are more well distributed in the Delaware River and action area than previously thought (ERC 2007).

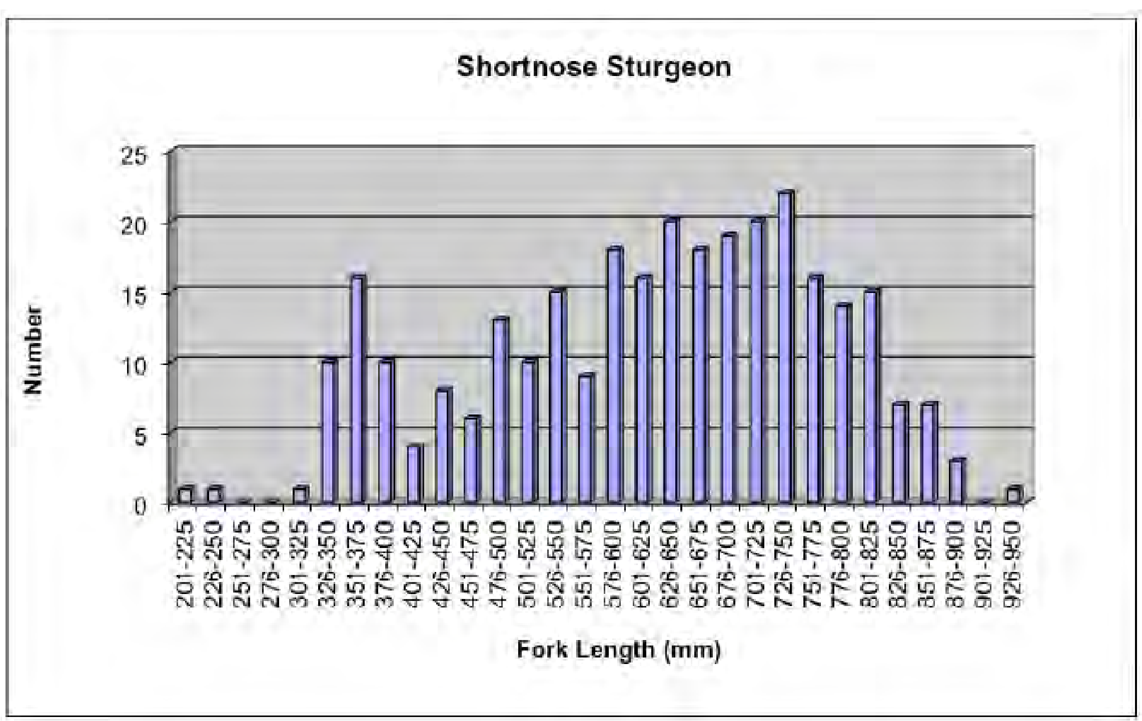

Figure 6-2. Length-Frequency Distribution for Shortnose Sturgeon Collected During Relocation Trawling, 2016-17 (ERC 2017)

Adults

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.

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 1993). The capture of multiple shortnose sturgeon at the Cherry Island Flats at RKM 119 during the summer months (Shirey 1999 and 2006) indicates that shortnose sturgeon are likely to be foraging here in this summer and that it may serve as a summer concentration area.

By the time water temperatures have reached 10°C, typically by mid-November[18], most adult sturgeon have returned to the overwintering grounds around Duck Island and Newbold Island. These patterns are generally supported by the movement of radio-tagged fish in the region between RKM 201 and RKM 238 as presented by Brundage (1986). Based on water temperature data collected at the USGS gage at Philadelphia, in general, shortnose sturgeon are expected to be at the overwintering grounds between early November and mid-April. A large number of adult shortnose sturgeon overwinter in dense sedentary aggregations in the upper tidal reaches of the Delaware between RKM 190 and 211. The areas around Duck Island and Newbold Island seem to be regions of intense overwintering concentrations. However, unlike sturgeon in other river systems, there is 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 (Versar 2006) documented two sturgeon of unknown species at Marcus Hook and 1 sturgeon of unknown species at Tinicum. Gillnetting in these same areas caught only one Atlantic sturgeon and no shortnose sturgeon. Video surveys of the known overwintering area near Newbold documented 61 shortnose sturgeon in approximately 1/3 of the survey effort. This study supports the conclusion that the vast majority of adult shortnose sturgeon overwinter near Duck and Newbold Island.

Brundage (2004) 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

[18] 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).

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 [WHAT SEASON?] 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 Crowns Landing LNG 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.

In 2005, the USACE conducted investigations to determine the use of the Marcus Hook region by sturgeon. Surveys for the presence of Atlantic and shortnose sturgeon were conducted between March 4 and March 25, 2005 using a video mounted on 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. 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.

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. 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, in general, fish that encountered the sled between the leading edge of the sled runners were relatively easy to distinguish. 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. 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. Adjusting for differences in water clarity and distance of observation, approximately 10 times more sturgeon were encountered in the upriver area relative to the project site near Marcus Hook where three sturgeons were observed. 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 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, newer data shows that not all adults move to overwintering areas near Duck and Newbold Island and indicate that adult shortnose sturgeon are present in the Marcus Hook area during the winter in larger numbers than previously predicted. During the relocation trawl pilot study in the Marcus Hook Anchorage (RKM 127-139) from January 25-March 7, 2014, 67 shortnose sturgeon were collected in less than 8 hours of trawling. Of the 67 shortnose sturgeon collected, 48 were adults, indicating that the Marcus Hook area is used by adult as well as juvenile shortnose sturgeon (Brundage and O'Herron 2014). Similarly, the relocation trawl conducted during November 15 to March 15 of the winter 2016-2017 collected 231 adults at approximately RKM 108-136.8 below the proposed marine terminal site (ERC 2017). These data further demonstrate the use of the river channel adjacent to and below the site of the proposed marine terminal by adults as well as juveniles.

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.

6.4.1.3 Summary of Shortnose Sturgeon Presence in the Action Area

The action area does not include spawning sites. Consequently, eggs and yolk sac larvae are not present within the action area. Because of lack of information indicating otherwise, we consider post yolk sac larvae to be present within the action during spring and extending into June. Young-of-Year are have been documented within the action area during late fall and may be present year round. Both juvenile and adult shortnose sturgeon are present in the action area from the Marcus Hook range through the Tinicum Range during summer and winter in larger numbers than was previously considered. Both juveniles and adults have been documented adjacent to the project site. We consider shortnose sturgeon to use the reach above Little Tinicum Island mostly for spring and fall migration to and from upstream overwintering and downstream summer foraging areas.

We do not know the habitat preference of larva once they settle or of early YOY. We presume they forage over soft substrate. Given their limited swimming ability and their prey, we consider these life stages to occur in shallower areas with low velocity currents such as near shore areas and inside bends of the Delaware River. Given the location of the project site at an inside bend,, the substrate at the site, presence of SAV, and the depth, larvae and YOY are likely to use the project site for foraging.

Older juvenile and adult shortnose sturgeon also forage over soft substrate and areas with submerged aquatic vegetation. Limited data suggest that these life stages are generally found at waters 6 meter (20 feet) deep but likely also opportunistically forage in shallower areas. Given the soft substrate, depth, and presence of SAV at the berth site of the proposed marine terminal, we are reasonably certain that juvenile and adults use the terminal berth area. During winter, they may use deeper areas of the river channel. However, best available data and information show that within the action area, adults and juveniles are not stationary during winter but are rather active and distribute widely within the river channel.

6.4.2 *Atlantic sturgeon in the Delaware River*

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 (Simpson 2008). All historical Atlantic sturgeon habitats appear to be accessible in the Delaware (ASSRT 2007).

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 Cobb (1899) and Borden (1925) reported spawning between RKM 77 and 130 (Delaware City, DE to Chester City, PA). Based on tagging and tracking studies, 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 (river kilometer 125) and the mouth of the Schuylkill River (river kilometer 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 (river kilometer 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 to100 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 2015 Annual meeting of North American Sturgeon and Paddlefish Society (Oshkosh, WI) by DiJohnson *et al.* (2015), recorded the movements of 7 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 7 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% 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 (Fisher 2009; Calvo *et al.* 2010). Twenty of the Atlantic sturgeon YOY (less than 30 cm FL) 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 2009 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. 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 (2014) 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 of the deepening of the Federal Navigation Channel (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. During this season, Altantic sturgeon captured again represented fish from the young-of-year and juvenile age classes. See a model distribution in Figure 6-3.

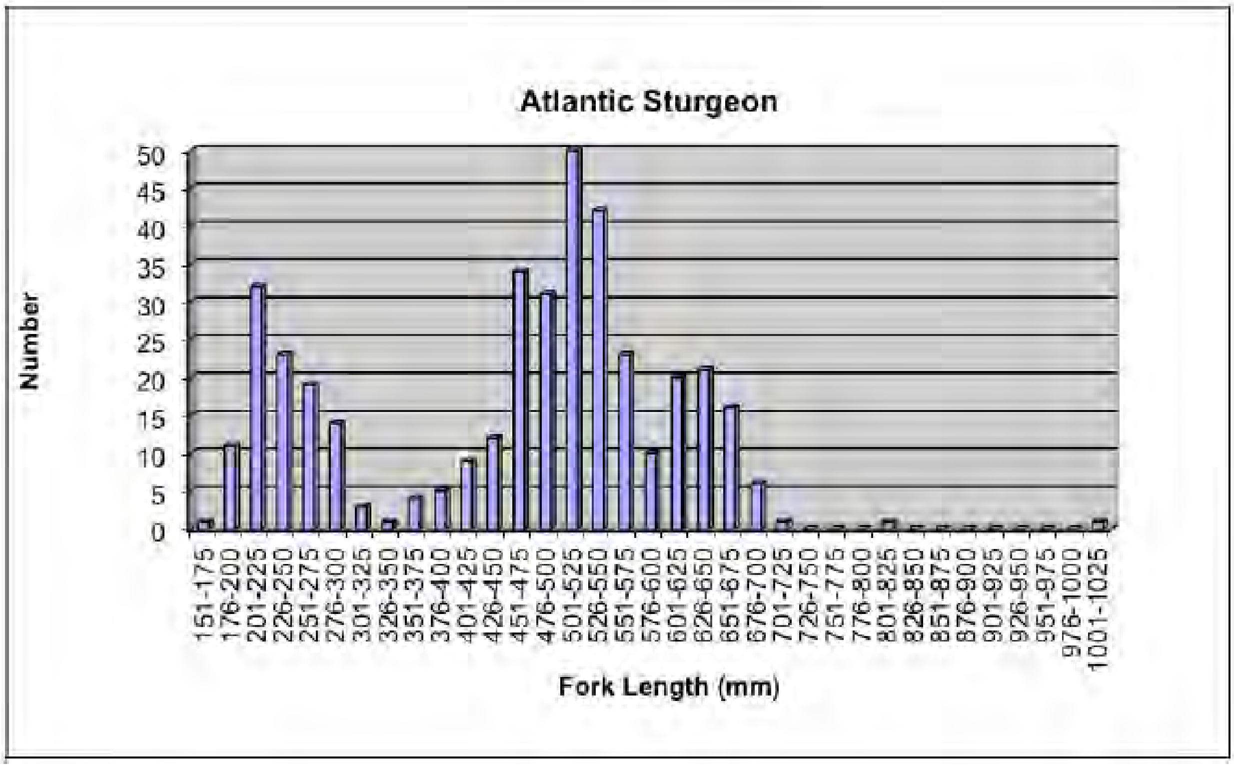

Figure 6-3: Length-Frequency Distribution for Atlantic Sturgeon Collected During Relocation Trawling, 2016-2017, ERC 2017

The Delaware Estuary is known to be a congregation area for sturgeon from multiple DPSs. Generally, non-natal late stage juveniles (also referred to as subadults) immigrate into the estuary in spring, establish home range in the summer months in the river, and emigrate from the estuary in the fall (Fisher 2011). Subadults tagged and tracked by Simpson (2008) entered the lower Delaware Estuary as early as mid-March but, more typically, from mid-April through May. Tracked sturgeon remained in the Delaware Estuary through the late fall departing in November (Simpson 2008). Previous studies have found a similar movement pattern of upstream movement in the spring-summer and downstream movement to overwintering areas in the lower estuary or nearshore ocean in the fall-winter (Brundage and Meadows 1982, Brundage and O'Herron 2009, Lazzari *et al.* 1986, Shirey *et al.* 1997). Breece *et al.* (2016) tracked 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 (Calvo *et al.* 2010, Simpson 2008) as well as near Artificial Island (Simpson 2008). Sturgeon have also been detected using the Chesapeake and Delaware Canal (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.

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). 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 Altantic 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 coarsegrained 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 Alantic sturgeon is occurring in the Delaware River.

Subadults from any of the five DPSs could be present in the action area; this life stage is most likely to be in the action area from mid-April to mid-November although some subadults may overwinter in the river and be present year round. Adults are only likely to be present in the river for approximately a four week period from mid-April to mid-June, dependent on annual water temperature. Nearly all adults in the river are likely to originate from the New York Bight DPS, but tracking indicates that occasionally adults are present in rivers outside their DPS of origin In the action area, any eggs, larvae, or young of the year (juveniles) would only originate from the New York Bight DPS because these life stages are restricted to their natal river..

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

6.4.2.1 Expected Seasonal Distribution of Atlantic Sturgeon from Philadelphia to the Sea

The discussion below will summarize the likely seasonal distribution of Atlantic sturgeon in the river reaches. 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 (Delaware River Basin Commission 2017)

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 juveniles likely overwinter closer to the salt front and within the Chester Range (ERC 2017). Early life stages will not be present in Reach E.

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. Based on recent relocation trawling, salinity tolerant juveniles likely overwinter closer to the salt front and within the Chester Range (ERC 2017). Early life stages will not be present in Reach D.

Reach C encompasses the area from RKM 89-108 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 channel (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. The salt front does seasonally dip into Reach C, so young-of-year and post yolk-sac larvae (April through September) could also be present in the upper stretch of 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 April 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 April through September.

6.4.2.2 Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Delaware River and estuary. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Delaware River, and thereby, in the action area, will have originated from the Delaware River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Delaware River and estuary would not be limited to just individuals originating from the NYB DPS. Based on mixed-stock analysis, we have determined that subadult and adult Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: Gulf of Maine 7%; NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; and Carolina 0.5%. These percentages are largely based on genetic sampling of individuals (n=105) sampled in directed research targeting Atlantic sturgeon along the Delaware Coast, just south of Delaware Bay (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% of the fish, James River accounting for 17-18%, Savannah/Ogeechee/Altamaha 17-18%, and Kennebec 9-11%. The range in assignments considers the slightly different percentages calculated by treating each sample individually versus treating each fish individually (some fish were captured in more than one of the years during the three year study). Carolina DPS origin fish have rarely been detected in samples taken in the Northeast and are not detected in either the Delaware Coast or in-river samples noted above. However, mixed stock analysis from one sampling effort (i.e., Long Island Sound, n=275), indicates that approximately 0.5% of the fish sampled were Carolina DPS origin. Additionally, 4% of Atlantic sturgeon captured incidentally in commercial fisheries along the U.S. Atlantic coast north of Cape Hatteras, and genetically analyzed, belong to the Carolina DPS. Because any Carolina origin sturgeon that were sampled in Long Island Sound could have swam through the action area on their way between Long Island Sound and their rivers of origin, it is reasonable to expect that 0.5% of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2013).

7 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 2047). 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

7.1 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 reasonably 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 (IPCC 2014). 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 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 (IPCC 2007; Greene *et al.* 2008). 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 2007). The NAO impacts climate variability throughout the Northern Hemisphere (IPCC 2007). 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 2007). 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 (IPCC 2007). 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 (IPCC 2007; Greene *et al.* 2008). 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 2001). 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 2001). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

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). 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 0.2ºC per decade; and 3) a rise in sea level (NAST 2001). 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.* (2016a) 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.

7.2 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 (City Planning 702 Urban Design Studio 2008) and the availability of water for human use (*e.g.*, Ayers *et al.* 1994). Documents prepared by the USACE for the deepening project have considered climate change (USACE 2009, 2011a), with a focus on sea level rise and a change in the location of the salt line.

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

The report notes that the Mid-Atlantic States are anticipated to experience sea level rise greater than the global average (GCRP 2009). While the global sea level rise is largely attributed to melting ice sheets and expanding water as it warms, there is regional variation because of gravitational forces, wind, and water circulation patterns. In the Mid-Atlantic region, changing water circulation patterns are expected to increase sea level by approximately 10 cm over this century (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 *et al.* (2010), 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 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 RKM166 during a period of severe drought in 1965; thus, he predicts that over time, during certain extreme conditions, the salt line could shift up to 18 km further upstream by 2050 and 23 km further upstream by 2100.

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 to deepen river channels can also impact salinity, but suggested that dredging of the Delaware River Federal Navigation Channel at Chester to increase depth to 45 feet 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. A 2007 examination of long-term data in Delaware River water temperature shows no indication of any long-term trends in these seasonal changes (BBL Sciences 2007). Monthly mean temperature in 2001 compares almost identically to long-term monthly mean temperatures for the period from 1964 to 2000, with lowest temperatures recorded in April (10–11°C) and peak temperatures observed in August (approximately 26–27°C). 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 (Ross *et al.* 2015). Air temperature has been used for coastal and freshwater water temperature trends (Tommasi *et al.* 2015) so it 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*. (in review) over the time period of the action (2017-2047), 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.

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

As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on shortnose and Atlantic sturgeon. We have analyzed the available information, however, to consider likely impacts to sturgeon in the action area. We consider here likely effects of climate change during the period from now until 2047 – the duration of the effects from the proposed marine terminal.

Over time, the most likely effect to shortnose and Atlantic sturgeon would be if sea level rise was great enough to consistently shift the salt wedge far enough north which would restrict the range of juvenile sturgeon and may affect the development of these life stages. Upstream shifts in spawning or rearing habitat in the Delaware River are not limited by any impassable falls or manmade barriers. Habitat that is suitable for spawning is known to be present upstream of the areas that are thought to be used by shortnose and Atlantic sturgeon suggesting that there may be some capacity for spawning to shift further upstream to remain ahead of the saltwedge. Based on predicted upriver shifts in the saltwedge, areas where Atlantic sturgeon currently spawn could, over time, become too saline to support spawning and rearing. Modeling conducted by the USACE indicates that this is unlikely to occur before 2040 but modeling conducted by Collier (2011) suggests that by 2100, 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.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations through the area as sturgeon move throughout the river. There could be shifts in the timing of spawning. Presumably, if water temperatures warm earlier in the spring, and water temperature is a primary spawning cue, spawning migrations and spawning events could occur earlier in the year. Spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change). It is 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). Low DO levels during the warmer season has historically affected and restricted shortnose sturgeon movements in the Delaware River and was considered an explanatory factor for why sturgeon was not found downstream of Philadelphia, Pennsylvania. Since the late 1990s, water quality and DO levels have improved drastically with shortnose sturgeon juveniles and adults distributing downstream to the salt front to forage during spring, summer, and fall. Thus, if DO levels again decrease below critical levels in lower reaches of the river, shortnose sturgeon distribution might again be restricted to the upper reaches of the tidal Delaware River. The lower tidal river and salt-freshwater mixing zone is important production areas in estuaries. If DO levels around Philadelphia again decrease to levels avoided by sturgeon, then this will substantially cut off important foraging and growth areas for shortnose sturgeon.

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 (see 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, Ziegeweid *et al.* 2008), 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 (*e.g.*, Mobert 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, we could expect that over time, sturgeon would shift out of shallow habitats on the warmest days. This could result in reduced foraging opportunities if sturgeon were foraging in shallow waters.

As described above, over the long term, global climate change may affect shortnose and Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species which may allow them to deal with change better than predicted.

The overall vulnerability of Atlantic sturgeon to climate change has been found to be very high (Hare *et al*. 2016a). The Nature Conservancy used the following recommended criteria for successful recruitment of Atlantic sturgeon in the Delaware River when examining impacts of flow, DO, and saltwater encroachment: 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 (Moberg and DeLucia 2016). However, 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.

8 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species, together with the effects of other activities that are interrelated or interdependent, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. In this Opinion, we consider the likely effects of the action and any interrelated and interdependent actions that have not yet been completed on ESA-listed sturgeon under our jurisdiction and their habitat in the action area within the context of the species' current status, the environmental baseline, and cumulative effects.

The activities have the potential to affect sturgeon in several ways: exposure to increased underwater noise resulting from pile installation; vessel interactions; changes in water quality, including TSS and pollutants; and alterations of the abundance or availability of potential prey items. The effects analysis below is organized around these topics. We also include effects from activities related to the long-term operation of the terminal. Activities include the transport, off- and on-loading, and storage of cargo; disposal and intake of ballast; and upland storm-water run-off from upland facilities. These activities have the potential to affect listed species and habitat through vessel interactions, degraded water quality, and catastrophic spills. These effects are also factored into the Integration and Synthesis of Effects (Section 10) as section 7(a)(2) of the ESA applies to the action as a whole, and not just the components authorized by the USACE.

8.1 Construction of Terminal

This section considers the effects of dredging, considering the risk of entrainment or impingement of sturgeon, the effects of dredging and dredged material disposal on water quality, and the effects of dredging and dredged material disposal on habitat. Where applicable, effects of the hydraulic and mechanical dredging are reviewed separately. This section also addresses maintenance dredging and material disposal for the proposed marine terminal through 2047. Maintenance dredging would be conducted by mechanical dredging. The effects of vessel traffic associated with dredging are evaluated together with construction related vessel traffic in Section 8.1.5.

All construction activities will occur at the site of the proposed Gibbstown Terminal and Logistic Center located at the site of the former Dupont Repauno Works in Gibbstown, Gloucester County, New Jersey, at RKM 137 (river mile 86.5). Project vessels will travel downstream four miles or upstream approximately 15 miles from the project site. Thus, all construction related activities will occur in the tidal reach of the Delaware River, upstream of RKM 133 (RM 83) and about 96 RKM upstream of the Delaware River mouth to the Delaware Bay located at RKM 77. Sturgeon are present in this reach of the river all year and will be exposed to stressors from construction activities.

8.1.1 *Water Quality from Dredging*

8.1.1.1 Suspended Sediment and Turbidity

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).

Dredging activities to remove fine-grained silt would suspend sediment within the water column, resulting in a short-term increase in turbidity. High concentration of suspended sediment or turbidity may affect fish through many pathways (Kjelland *et al.* 2015). It may directly harm fish by clogging their gills, increase stress, or interfering with their ability to find prey and avoid predators. Turbidity may also have indirect effects on sturgeon through the burial of benthic prey or creation of a barrier to movement within the river. Resuspension of impacted sediments could affect sturgeon directly (i.e. acute toxicity) or indirectly through ingestion of exposed prey.

Effect Thresholds for Total Suspended Sediment (TSS) and Turbidity

Literature reviews of effects of suspended sediment on fish show that effects varies greatly among species and suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993, Kjelland *et al.* 2015, Wilber and Clarke 2001). Burton (1993) evaluated effects of bucket dredging in the Delaware River and determined that lethal effects on fish due to turbid waters can occur at levels between 580 mg/L to 700,000 mg/L, depending on the species. The studies reviewed by Kjelland *et al.* (2015) found that, depending on species, reported mortality ranged from 10 to 100 percent when exposed to TSS levels ranging from 300 to 300,000 mg/L after exposure periods ranging from 24 to 48 hours. Wilber and Clarke (2001) found that for adult estuarine species, TSS effects ranged from “no effect” when exposed to 14,000 mg/L for a duration of three days for two species to the lowest observed concentration that caused mortality at 580 mg/L after one day of exposure for Atlantic silverside. The concentration of suspended sediment is not the only factor determining effects but also the duration at which a fish is exposed. Most studies report response after exposure ranging from 24 to 48 hours.

Sublethal effects have been observed at lower turbidity levels. For example, Sutherland *et al.* (2008) reported that two freshwater minnow species experienced physiological stress (measured as increased stress hormone levels) when exposed to suspended sediment concentration of 100 mg/L for a 48 hour period. Stress can result in abnormal behavior, immunosuppression, and reductions in growth rate, egg production, thermal tolerance, and swimming stamina (Barton 2002, Wedemeyer *et al*. 1984, Davis *et al*. 1985). However, the two minnow species occupy clear upland freshwater streams and are considered highly sensitive to elevated suspended sediment concentrations. Redding *et al.* (1987) observed stress at relatively high concentration in yearling coho salmon and steelhead at treatments of TSS levels of 2000–3000 mg/L over two days. Suspended sediment can also decrease oxygen absorption by the gills. The physiological response is an increase in red cell counts, hematocrit (increased volume percentage of red blood cells in blood), and hemoglobin consternation in the blood circulation system. Increased hematocrit levels in estuarine species have been reported for TSS concentrations above 600 mg/L (Wilber and Clarke 2001). At the low end of concentration, white perch showed increased blood hematocrit when exposed to 650 mg/L for five days. At the high end of concentration and duration, striped bass showed increased hematocrit after 14 days of exposure at 1,500 mg/L.

There have been no directed studies on the physiological effects of TSS on shortnose or Atlantic sturgeon. However, Kjelland *et al.* (2015) noted that benthic species in general are more tolerant to suspended sediment than pelagic species. Shortnose and Atlantic sturgeon juveniles and adults are often documented in turbid water and Dadswell *et al.* (1984) reports that shortnose sturgeon are more active under lowered light conditions, such as those in turbid waters. As such, shortnose and Atlantic sturgeon are assumed to be as least as tolerant to suspended sediment as other estuarine fish. Therefore, we regard sublethal and lethal effects on juvenile and adult Atlantic sturgeon and shortnose sturgeon to occur when exposed to 24 hours of concentrations at or above 580 mg/L.

As is the case with physiological effects, behavioral response to increased turbidity and turbidity plumes varies among species and depends on their specific biology such as sensory capabilities and adaptive strategies. Studies of how fish respond to suspended sediment have detected a behavioral effects of turbidity on feeding and vulnerability to predation (Kjelland *et al.* 2015, Wilber and Clarke 2001). High turbidity may affect feeding efficiency for species using visual detection during foraging, which again can result in reduced growth, fecundity or increase stress and susceptibility to disease and parasites. However, turbidity, at least at TSS levels below what would cause physiological effects, is not likely to substantially affect Atlantic sturgeon or shortnose sturgeon foraging. Sturgeon typically occur in turbid waters and Atlantic sturgeon and shortnose sturgeon forage by rooting along the bottom with their snout in search for benthic prey that they grasp with their protruberant mouth (Gilbert 1983, Kynard *et al.* 2016). During foraging, they use their barbels as sensory organs to detect prey (Hilton *et al.* 2016, Kynard *et al.* 2016). Both species also actively forage during night (Dadswell *et al.* 1984). Based on foraging method, tolerance to high turbidity, and foraging during night it is unlikely that visual detection of prey is of major importance for Atlantic sturgeon and shortnose sturgeon foraging success. Elevated TSS levels resulting in physiological effects may elicit avoidance behavior and movement away from turbidity plumes. Studies on another an anadromous species, striped bass, showed that pre-spawners did not avoid TSS concentrations of 954 mg/L to 1920 mg/L to reach spawning sites (Summerfelt and Moiser 1976, Combs 1979 in Burton 1993).

High TSS levels and turbidity that affect prey such as benthic invertebrates can indirectly affect fish by reducing abundance of forage or changing the composition of prey away from the preferred forage (Kjelland *et al.* 2015). Suspended sediment at TSS levels at or higher than 590 mg/L can negatively affect benthic communities (EPA 1986).

Exposure

The life stages of fish most vulnerable to increased sediment are eggs and larvae which are subject to burial and suffocation (Kjelland *et al.* 2015). However, as noted above, no sturgeon eggs and/or larvae will be present in the action area because dredging will occur and be completed when these life stages are not present in the Delaware River. Juveniles of both sturgeon species will be present at or in the vicinity of the project site during the period when dredging will occur as will adult shortnose sturgeon. Most subadult and adult Atlantic sturgeon are expected to have moved into downstream estuarine waters with higher salinity, into the bay, or migrated into marine waters in late fall (about November) (Brundage and Meadows 1982, Brundage and O'Herron 2009, Brundage and O'Herron in Calvo *et al.* 2010, Lazzari *et al.* 1986, Shirey *et al.* 1999, Shirey *et al.* 1997). Generally, subadults, including non-natal sturgeon, and adults immigrate into the estuary as early as mid-March but more typically from mid-April through May. They then move upstream and establish home range in the summer months in the river (Fisher 2011, Simpson 2008). However, some subadults may still be present during winter and early upriver movements and staging of adult Atlantic sturgeon may occur in March. Thus, juveniles and adults of both species may be exposed to suspended sediment during dredging of the berth (December 2017 to April 1, 2018). Spawning by Atlantic sturgeon starts in mid-April and may continue through July. Therefore, dredging will not expose adult Atlantic sturgeon to elevated turbidity during spawning.

Suspended Sediment Levels during Dredging and Material Disposal

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 152, 305, 610 and 1006 meters (500, 1,000, 2,000 and 3,300 feet) from dredge sites in the Delaware River and were able to detect concentrations between 15 mg/L and 191 mg/L up to 610 meters (2,000 feet) from the dredge site. Analyses of mechanical dredging activities using a clamshell style dredge bucket indicate that increased sediment levels at the near bottom will be fully dissipated at a distance of approximately 700 meters (~2,300 feet) from the dredge site if dredging silt (Bohlen *et al*. 1979). 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 183 meters (600 feet) of the source in the upper water column and 732 meters (2,400 feet) 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 732 meters (2,400 feet) of the dredge location.

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 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).

Material Disposal

As described in Section 3.3, dredged material will be allowed to settle and the water pumped into decant barges where the water will be allowed to settle. Free water would not be discharged back to the river sooner than 24 hours, and only if the concentration of total suspended solids (TSS) is less than 30 mg/l as required by NJDEP. A concentration of 30 mg/L is less or equal to background levels in the Delaware River and decanting will not increase TSS in receiving waters.

Certain dredged materials would be transported to one of two permitted CDFs located on the Delaware River. Identified dredged material disposal facilities at Whites Basin and Fort Mifflin are located at approximately RKM 132 (RM 82) and RKM 147.3 (RM 91.5), respectively. Materials placed at the Ft. Mifflin CDF would be hydraulically pumped directly from the barge to the upland CDF. Discharge of return water from a CDF is required to comply with Federal and state water quality regulations including Section 401 Water Quality Certification and site-specific hydrodynamic and water quality monitoring requirements. Dredged material that does not meet Whites Basin or other CDF acceptance criteria (i.e., sediment contamination criteria) would be transported to the Weeks Marine facility in Camden, New Jersey for processing and upland disposal in a permitted landfill. State and federal permitting of upland landfill facilities requires that stored sediments are confined to the facility and are prevented from reentering waterways. Thus, there is no pathway for effects to listed species through terrestrial disposal at a permitted facility.

The proposed disposal of material at Whites Basin by barge will cause a temporary increase in the amount of turbidity in the semi-enclosed basin and TSS is expected to be equal to what occur during dredging (445 mg/L). Suspended sediment is expected to settle out of the water column within a few hours and any increase in turbidity will be short term. Turbidity levels associated with the placement of material within the basin are likely to remain primarily within the basin, though a small plume may extend into the Delaware River if sediment is placed near the confluence of the basin mouth and the Delaware River.

Effects of Elevated TSS

Juvenile and adult sturgeon are frequently found in turbid water and would be capable of avoiding any sediment plume by swimming higher in the water column. Laboratory studies (Niklitschek 2001, Secor and Niklitschek 2002) have demonstrated shortnose sturgeon are able to actively avoid areas with unfavorable water quality conditions and that they will seek out more favorable conditions when available. Additionally, the highest TSS levels expected for any of the dredging is up to 445 mg/L. This level are below those shown to have lethal and sublethal effect on estuarine fish (≥580.0 mg/L for the most sensitive species).

To date, no sturgeon have been documented within Whites Basin. This may be due to the semi-enclosure of the disposal site and unsuitable habitat within the basin. As the basin is used frequently for disposal of dredged material and this material is being dredged for disposal at upland sites, the local benthic community is continuously disturbed, resulting in few benthic resources. In light of the limited benthic resources and resultant a lack of suitable prey for sturgeon, combined with frequent disturbances within the basin, shortnose sturgeon and Atlantic sturgeon are extremely unlikely to occur within the basin. Instead, shortnose sturgeon and Atlantic sturgeon are likely to bypass the opening of the semi-enclosed basin while migrating to other areas of the Delaware River that are more suitable for foraging, spawning, or other essential behaviors.

TSS level that would affect benthic communities could occur at TSS levels at or higher than 390 mg/L. With the exception of near field cutterhead dredge impacts, TSS levels will not reach levels that are toxic to benthic communities. As noted, TSS levels during dredging of the upper layer of fine sediment decreases quickly with distance from the dredge and will be equal to background levels within 732 meters of dredging activities. Dredging of sand will result in even lower concentration of susepended sediment and turbidity, since the much larger sand particles quickly settles out of the water column (Schroeder 2009). Thus, the highest suspended sediment concentrations will occur within a short distance of the dredge. We further 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 (immediately adjacent to the dredged area) of a cutterhead dredge may be buried/suffocated. Therefore, effects to sturgeon foraging opportunities from TSS impacts to benthic communities in the berth area, are largely temporary and limited to a small area (i.e., the near-field range of where cutterhead dredging will occur).

TSS is most likely to affect mobile sturgeon (juveniles and adults) 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. Even if the movements of sturgeon were affected, these changes would be small. The plume may extend 732 meters from the dredge but will quickly decrease to low concentrations as the distance increases from the dredging area and the sediment falls out of the water column. Further, a closed clamshell environmental bucket will be used to remove fine-grained sediments during mechanical dredging of the berth. In an USACE demonstration project at Boston Harbor in 1999, sediment resuspension and loading characteristics of a conventional (open-faced) clamshell bucket and an enclosed clamshell bucket were studied under similar operating and environmental conditions (USACE 2001). The depth-averaged TSS concentration for the Enclosed bucket was 160 mg/L less than for a conventional bucket (50 mg/L compared to 210 mg/L for the Conventional bucket). The Applicant must also implement best management practices (BMP) in accordance with the NJDEP Waterfront Development Permit issued for the project. The BMPs include:

- Controlling the rate of descent of the bucket to maximize the vertical cut of the clamshell bucket, while not penetrating the sediment beyond the vertical dimension of the open bucket (i.e., overfilling the bucket). The dredging contractor will use appropriate software and sensors to ensure consistent compliance with this condition;
- Using an environmental clamshell equipped with sensors to ensure complete closure of the bucket before it is lifted through the water at a rate of 2 feet per second (fps) or less;
- Controlling the "bite" of the bucket to: (a) minimize the total number of passes needed to dredge the required sediment volume and (b) minimize the loss of sediment due to extrusion through the bucket's vents openings or hinge area;
- Placing material deliberately in the barge to prevent spillage of material overboard;
- Using barges or scows with solid hull construction or hulls sealed with concrete to transport sediments;
- Discharging decant water only within the area to be dredged;
- Holding decant water in the decant holding scow for a minimum of 24 hours after the last addition of water to the scow. This holding time may be reduced if it can be demonstrated that TSS meets the background concentrations of 30 mg/L, based on three consecutive TSS analyses; and
- Not dragging the dredge bucket along the sediment surface.

Thus, we expect the TSS concentration and extent of the sediment plume to be less than 732 meters.

Any TSS levels that may cause avoidance will be closer to the dredging than the full extent of the sediment plume. The river channel at the project site is approximately 920 meters (3,020 ft.) wide from the bank of the old bulkhead to the banks of Little Tinicum Island. A shallower secondary channel exists on the Pennsylvania side of the island. Thus, any avoidance of the plume will not hinder upstream or downstream movements of sturgeon. Sturgeon feed on a large range of prey and actively move over the riverbed in search of forage when foraging. The small evasive movements that would be necessary to avoid high TSS concentrations would be within their normal range of movements and will not increase normal energy use.

Given that no egg or larvae will be present, that expected TSS levels expected for all activities are lower than what have been found adversely affecting juvenile and adult estuarine fish, that only benthic invertebrates in a narrow zone near the edge of the dredged area may negatively affected by suspended sediment, that ample foraging habitat exists in the river channel at the project site, that any avoidance of turbidity plumes will be small and not hinder normal essential behaviors, we conclude that the effects of suspended sediment on sturgeon resulting from proposed activities when added to baseline conditions will be so small that effects cannot be meaningfully detected, evaluated, or measured. Therefore, effects on sturgeon are insignificant.

8.1.1.2 Impacted Sediment

A stated above, a closed environmental clamshell dredge will be used to remove impacted sediments in the dredging area. Resuspension of contaminated sediments could affect sturgeon directly (i.e. acute toxicity) or indirectly through ingestion of exposed prey (i.e. may lead to chronic toxicity). Resuspension of sediments will only occur within a small portion of the dredging area where impacted sediments are present. Based on analytical testing, impacted sediments in the dredging area are contaminated with arsenic (four locations), chromium (two locations), and copper (one location) above the NJDEP FWSEL ecological screening level. Other contaminants of concern (COC), including PAHs and PCBs were also detected, but at concentrations below the FWSELs. Exceedance of the FWSEL indicates severe impacts to the benthic community in most cases studied (NJDEP). As discussed in Section 6.3.2, AECOM (2016) investigated sediment contamination near the existing wharf on behalf of the previous owner. Comparisons to a background dataset collected as a part of AECOM's evaluation indicate that concentrations of organic and inorganic constituents, as a whole, are consistent with background conditions in the Delaware River. The vast majority of resuspended sediments settle close to the dredge bucket within an hour and only a small fraction takes longer to resettle (Schroeder 2009). In addition, the resuspension rate of contaminated sediments is low (*e.g.* 0.3 to 2%) for closed environmental bucket dredges (Schroeder 2009) and dredging BMPs would be used to further minimize the sediment resuspension (see section 3.8.2).

Any exposure will occur when a sturgeon moves through a plume of contaminated sediment and will be temporary and of short duration. Because the types of toxins detected above standards are chemically bound to particles in the sediment, the main route of exposure is through bioaccumulation (consumption of benthic invertebrates with high levels of contaminants) rather than through direct exposure to the particles in suspension. Thus, the short duration of exposure to the contaminated suspended sediment is unlikely to result in direct toxic effects. Resettlement of the sediment could increase presence of the contaminants in benthic invertebrates if the resettled sediment contains concentrations that exceeds background toxicity levels. Since the effect of the detected contaminants are most likely to adversely affect sturgeon through bioaccumulation, it is possible that sturgeon could be adversely affected if the sediment settled in foraging areas that have low background levels of contaminants. Although sediments within the dredging plume may be contaminated, we do not expect resettlement of the sediment to result in an increase in contamination of bottom sediment in other areas of the river. This because a very small volume of sediment will be suspended and most of the suspended sediment will settle within the area being dredged. Any suspended sediment transported by currents into other areas of the Delaware River is extremely unlikely to result in increased contamination of the bottom substrate. This because chemical concentrations in the sediment at the project area do not exceed general background concentrations in Delaware River sediments. In other words, no indirect effects, or change from the baseline, are expected from resuspension and resettling of contaminated sediment because of this action, since dredging will not expose benthic prey to contaminant concentrations above existing background levels in river sediments within the action area. All effects to sturgeon will be too small to be meaningfully measured, detected, or evaluated. Effects are insignificant.

8.1.2 *Impingement/Entrainment*

The development of the proposed marine terminal involves mechanical dredging, using a closed clamshell bucket dredge or hard-digging bucket, and hydraulic dredging of sediments from the river bottom. Within the action area, dredging would be conducted within the dredging area shown on Figure 2-2 in the biological assessment for this project. Dredging activities would be completed by April 1, 2018.

The effects of dredging on sturgeon will differ depending on the type of dredge used and the life stage of the sturgeon (*e.g.* eggs, larvae, juvenile, subadult, adult) present at the time of dredging. Sturgeon larvae are vulnerable to entrainment in a dredge due to their small size and relatively weak swimming abilities. Because of the concern for entrainment of larvae, the Applicant has proposed to complete dredging before April 1, 2018, to avoid temporal overlap between dredging activities and presence of larvae and small juveniles. Thus, sturgeon larvae will not be present in the action area during the proposed dredging (after December 1, 2017, and before April 1, 2018).

As noted above, juveniles of both sturgeon species will be present at or in the vicinity of the project site during the period when dredging will occur as will adult shortnose sturgeon. Adult and subadult Atlantic sturgeon may be present though most subadult and adult Atlantic sturgeon are expected to have moved into downstream estuarine waters with higher salinity, into the bay, or migrated into marine waters in late fall (about November). Spawning by Atlantic sturgeon starts in mid-April and may continue through July. Therefore, dredging will not expose adult Atlantic sturgeon to interaction with dredging equipment during spawning. Interactions with the mechanical or hydraulic dredging equipment could entrain, impinge or capture sturgeon, resulting in death or injury. The potential risk of these interactions is discussed below.

8.1.2.1 Mechanical Dredging

The project will use a closed environmental clamshell bucket for removal of soft sediments and a hard-digging clamshell bucket for removal of dense sands. Hard-digging dredges are typically heavier and have a more powerful closing mechanism than soft-digging buckets (USACE 1975). A clamshell bucket operates via the penetration of the bucket's two jaws beneath the sediment and simultaneous lifting and closing of the jaws to remove the sediment. In order to be impacted by the dredge bucket, a sturgeon would have to be on the bottom directly under the bucket. For a sturgeon to be removed by mechanical dredge, it would need remain directly between the jaws of the bucket as the bucket is lowered on and into the sediment and the jaws are close. A sturgeon may also be impacted if it was struck by the dredge bucket as the bucket enters the waterway.

In rare instances, sturgeon have been captured in dredge buckets. The USACE reported four instances of sturgeon captured in dredge buckets along the US East Coast between 1990 and 2010 (USACE 2011b). The risk of interactions between the dredge buckets and sturgeon are thought to be highest in areas where sturgeon are known to concentrate, such as overwintering sites or foraging concentrations. Several studies have found that juveniles of both species of sturgeon concentrated downstream at Marcus Hook but also commonly use the Tinicum Range. However, foraging in this area may be more opportunistic and surveys in the Tinicum Range have reported lower concentrations than at Marcus Hook at RKM 127 (RM79) and in the Cherry Island Range at RKM 117 (RM 67.7). As described in Section 6.4, juveniles of both species and adult shortnose sturgeon may overwinter in the Tinicum Island Range but were found to be active and not concentrate in dense aggregations.

For the proposed mechanical dredging, the bucket will be lowered through the water column at a rate of 2 fps (0.61 m/s) onto the bottom substrate where the jaws are closed to grab sediment. Fish in general are sensitive to movements in the water column and are able to register small changes in water pressure. It is therefore highly likely that a sturgeon will detect and move away from an approaching dredge head if under or near it when it approaches. By the time mechanical dredging is expected to start, YOY will be large and powerful enough to escape the bucket. The small area that a bucket covers will also enable a sturgeon to escape from under it if still present as the bucket is placed onto the substrate.

Based on the low number of juvenile and adult sturgeon likely to be present within the dredge area, the relatively small area of the river bottom that the bucket interacts with at any one time, that sturgeon are likely to escape approaching buckets, and given the time of year restrictions of the action, it is extremely unlikely that sturgeon would be injured or killed by the dredge bucket during dredge operations within the dredging area. Effects of capture in dredge are discountable.

8.1.2.2 Hydraulic (Cutterhead) Dredging

Impingement or entrainment from hydraulic dredging may kill or injure sturgeon. Hydraulic dredges suck up a mixture of sediment and water from the bottom surface and transfer it via pipeline to a desired location. The cutterhead dredge operates with the dredge head buried in the sediment; however, a flow field is produced by the suction of the operating dredge head. The amount of suction produced is dependent on linear flow rates inside the pipe and the pipe diameter (Clausner and Jones 2004). High flow rates and larger pipes create greater suction velocities and wider flow fields. The suction produced decreases exponentially with distance from the dredge head (Boysen and Hoover 2009).

Entrainment of sturgeon by hydraulic dredge is relatively rare for projects on the Delaware River. 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. The Delaware River Main Stem and Channel Deepening Project used a hydraulic dredge to remove 3,594,963 cy of material in 2010, 1,100,000 cy in 2011, and 1,200,000 cy in 2012. In all cases, the dredge disposal area was inspected daily for the presence of sturgeon. No sturgeon or sturgeon parts were detected.

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 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 inches (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-inch pipe diameter and suction of 4.6m/s. This is slightly larger than the pipe on the dredge that will be used for dredging of the berth area (30 inches).

The risk of an individual sturgeon being entrained in a cutterhead dredge is difficult to calculate. However, based on the above information, we consider that the risk of a sturgeon being entrained by a cutterhead dredge is depend on the volume dredged, that the risk is highest during winter in areas where large concentration of overwintering sturgeon occur, that active sturgeon are able to detect and avoid the dredge head, and that a sturgeon will have to be within one meter of the dredge head to be entrained.

The proposed marine terminal will at maximum remove 118,000 cy of material in a onetime event by hydraulic dredge which is an order of magnitude less than annual dredging volumes for the Delaware River Main Stem and Channel Deepening Project. Further, 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 noted above and in section 6.4, dense overwintering aggregations of sedentary sturgeon do not occur in the reach of the Delaware River where the dredging will occur. However, juvenile and adult sturgeon may be present in the portion of the action area where dredging would occur. 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 River supports these assessments of risk, as none of the tagged sturgeon were attracted to or entrained in the operating dredges. Based on the low volume of material to be dredged, that very few sturgeon entrainments in cutterhead dredges that have been observed despite observers monitoring spoils during dredging of large volumes of sediment, the low density of sturgeon within the reach where the project site is located, that the sturgeon will be active during the dredging period and able to detect the dredge head, and that a sturgeon will have to be within one meter of the dredge head to be entrained, we conclude that it is extremely unlikely that the proposed hydraulic dredging will result in entrainment of shortnose sturgeon or Atlantic sturgeon. Effects from hydraulic dredging are therefore discountable.

8.1.3 *Habitat Modification*

Dredging activities would directly disturb the river bottom and alter the river bottom, potentially reducing availability of prey species or altering prey composition. The effects of deepening the berth on habitat would be limited to the dredging area and along the pipeline route from the dredging area (RKM 138.4, RM 86) to Whites Basin (RKM 132, RM 82) where the pipeline will disturb substrate as it is placed on the riverbed. Temporary elevated TSS concentrations caused by a sediment plume from dredging may also affect habitat quality in vicinity of the dredging area; these effects are discussed in Section 8.1.1. The dredging area may be used by adult, subadult (Atlantic) and juvenile sturgeon for foraging and migration. The dredging area is located several miles upstream of an important sturgeon concentration area at Marcus Hook (RKM 125.6, RM 78). Adult and juvenile sturgeon may occur within the project area year round and sturgeon larvae from April through September.

Spawning locations for Atlantic sturgeon within the Delaware River have not been ascertained, but spawning habitat is believed to generally occur between the salt line and the fall line near Trenton, NJ (Breece *et al.* 2013, Simpson 2008). Based on telemetry of spawning adults and occupancy modeling using sedimentological survey results for the Delaware River, Breece *et al.* (2013) identified two areas of high concentration near Chester, PA (RKM 130.4, RM 81) and Claymont, DE (RKM 125.5, RM 78), which may represent contemporary spawning locations. The proposed dredging area is located more than two miles from the two areas identified by Breece *et al.* (2013). The substrate within the dredging area is predominately sand. Substrate in the dredging area generally consists of silts and sands, with small rock piles within the access channel to the Federal navigation channel. However, as explained in section 4.2.1.1, it is extremely unlikely that a pile of such rocks would have the small interstitial spaces preferred by sturgeon for spawning and refuge, growth, and development of larvae. Shortnose sturgeon spawning grounds are located more than 40 miles up-river from the dredging area. Therefore, dredging activities will not affect Atlantic surgeon or shortnose sturgeon spawning habitat and will not affect refugia used by sturgeon larvae.

The nearest hard bottom substrate that can be used for spawning and refuge, growth, and development of larvae is located along the Federal Navigation Channel approximately 3 RKM downstream from the project site. The Federal Navigation Channel adjacent to the Project is dredged annually for maintenance of the -40 feet channel, and was recently deepened to -45 feet as part of the Delaware River Main Channel Deepening Project. Due to the time of year when dredging will occur (December through March), spawning adults are not expected to be present; thus, there would be no direct disruption of spawning activity. No eggs will be present during this time of year and all larvae are likely to have developed to a mobile stage which reduces their vulnerability to the proposed action. No changes in substrate type or water depth will occur adjacent to the dredging area. Therefore, we do not expect that dredging would affect adjacent substrate in any way that reduces the suitability of spawning sites, the selection of spawning locations by adults, or the success of development of any eggs or larvae.

For hydraulic dredging only, dredge material would be transported via a submerged pipeline to the Whites Basin CDF approximately four miles downstream. Deployment of the pipeline would temporarily impact a narrow band of benthic habitat in the action area extending from the dredging area to Whites Basin. Based on dredging volumes, the pipeline would be deployed for approximately 10 to 12 days. The pipeline would not be deployed between after April 1, 2018, when all dredging are proposed completed and would not permanently alter the bottom substrate. Therefore, placement of the pipeline would not disrupt sturgeon spawning habitat and would not affect refugia for sturgeon larvae. Deployment of the pipeline may have a temporary negative impact on foraging habitat, if sessile benthic organisms are buried under the pipes during placement of the pipeline. Given the temporary nature of the deployment (less than two weeks), the small area affected (less than 1 acre), and large area of foraging habitat available to sturgeon in this portion of the river, the loss of a small number of benthic organisms will not result in effects that we can meaningfully measure, detect, or evaluated. Effects from habitat modification are insignificant.

Dredging would temporarily reduce foraging habitat in the dredging area and may impact local composition of shallow water benthic community. For the majority of the dredging area (~ 70%), changes in water depth due to dredging would be less than 10 feet. Wilbur and Clarke (2007) demonstrated that benthic communities in temperate regions with substrate of sand, silt, or clay recover from channel dredging between 1 month and 4 years after the disturbance, with an average recovery time of approximately 11 months. Based on this information, it is expected that benthic communities within the majority of the dredging area would recover within one year of dredging. Maintenance dredging is expected to be required approximately every 10-15 years. Therefore, the benthic community is anticipated to recover between dredging events. Dredging in subtidal, intertidal and SAV areas would result in a permanent loss of 1.36 acres of potential foraging habitat. Ample food resources are available outside the dredging area including approximately 45 acres of shallow water habitat along the shoreline of the proposed marine terminal that would not be disturbed by dredging or port operations. Additionally, losses to subtidal and intertidal areas would be mitigated through the purchase of wetlands credits and the loss of SAV would be mitigated through an SAV restoration project. Dredging within the action area is not expected to reduce availability of forage to sturgeon to the degree where a reduction in growth, survival, or reproduction of Atlantic sturgeon or shortnose sturgeon could be meaningfully measured, detected, or evaluated. Therefore, effects from habitat modification due dredging activities are insignificant.

8.1.4 *Pile Driving*

The driving and removal of piles generate sound waves that travels through the water body. Exposure to human generated sounds may potentially affect communication with conspecifics (members of the same species), effects on stress levels and the immune system, temporary or permanent loss of hearing, damage to body tissues, mortality, and mortality or damage to eggs and larvae. Moreover, exposure to high sound levels can result in potential long-term effects that might show up hours, days, or even weeks after exposure to sounds.

Sound is an important source of environmental information for most vertebrates (Buhler *et al.* 2015, Halvorsen *et al.* 2011). Fish use sound to learn about their general environment, the presence of predators and prey, and, for some species, for acoustic communication. As a consequence, sound is important for fish survival, and anything that impedes the ability of fish to detect a biologically relevant sound, *e.g.*, anthropogenic sound sources, could affect individual fish. Further, it studies and observations show that underwater sound pressure waves can directly injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001).

The applicant proposes to use land-based vibratory equipment to remove 63 remnant 12-inch diameter timber piles in the construction area prior to pile driving for construction of the new dock and wharf. The 12-in diameter timber piles would be removed from below mean high water.

Following the demolition of the old structures, a barge with pile driving equipment will be used to install pilings for the new berth structures. In all, 360 steel pipe piles and an unspecified number of H steel piles and steel sheet piles will be needed for the construction. Of the pipe piles, 43 are 36-inch diameter piles, 289 are 30-inch diameter piles, and 28 are 24-inch diameter piles. Driving of piles generates sound pressure waves that travels through surrounding water bodies. The frequency and intensity of these pressure waves depends on a variety of factors including the size of the piles, material of piles, installation method, kind of substrate the piles are driven through, depth, in-water obstructions, and other factors (Buehler *et al.* 2015). Pile driving may expose aquatic species to sound pressure traveling through water body resulting in effects ranging from startle response to physiological injury and death. Factors that contribute to the likelihood of an adverse effect include size, species of organism, condition of individuals, distance to the source, and behavioral response to exposure (Buehler *et al.* 2015).

In this section, we present background information on acoustics and analysis of exposure; a summary of available information on sturgeon hearing; a summary of available information on the physiological and behavioral effects of exposure to underwater noise; and the established thresholds and criteria to consider when assessing impacts of underwater noise. We also present the results of the Fish and Hydroacoustics Working Group' review of hydroacoustic pressure levels and effects on fish to help inform the analysis[19]. We then present empirical data and modeling provided to establish the noise associated with pile installation and consider the effects of exposure of individual sturgeon to these noise sources.

8.1.4.1 Sturgeon Likely to be exposed to Increased Underwater Noise

Sound in water follows the same physical principles as sound in air. The major difference is that due to the density of water, sound in water travels about 4.5 times faster than in air (approx. 4900ft./s vs. 1100 ft./s), and it attenuates much less rapidly than in air. As a result of the greater

19 http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm

speed, the wavelength of a particular sound frequency is about 4.5 times longer in water than in air (Rogers and Cox 1988; Bass and Clarke 2003).

The applicant has committed to complete all pile driving by April 1, 2018. Thus, pile driving will occur before the sturgeon spawning period, and Atlantic sturgeon will not be exposed to sound from pile driving during spawning. However, adults, especially males, may start moving into the river and upstream towards spawning sites before the spawning period and pile driving can expose spawning Atlantic sturgeon to elevated sound when they migrate upstream or staging before spawning. Shortnose sturgeon spawn outside (i.e., upstream) of the action area and adult spawners will not be exposed to noise generated by pile driving. Juveniles of both species nurse in the fresh and low salinity tidal reaches of the river. Juveniles of both species and adult shortnose sturgeon have been shown to be present during the winter in the reach where the project site is located and winter movements suggest that they forage during the winter. The deep navigation channel travels between Little Tinicum Island and the Dupont Repauno Works site and sound waves from the pile driving will extend into the navigation channel. Further, water depth at the project site is 35 feet at MLLW and would be deeper during high tide. No study of the benthic community at the site is available but the presence of mud and sand substrate as well as the fact that the site has not been dredged for at least 10 years suggest that benthic forage exists. Based on the above, juveniles of both species, subadult Atlantic sturgeon, and non-spawning adult Atlantic sturgeon and shortnose sturgeon are likely present within or near the project site. It is, therefore, reasonably certain that pile driving will expose them to elevated sound.

Atlantic sturgeon spawning habitat exists in areas both upstream and downstream of the project site and spawning may last into late June and early July. The length of the larval stage depends on temperature and can last for up to 50 days post hatch. Thus, larvae can be present in the river into September. Since pile driving will occur after October 2018 and before April 1, 2018, no larvae will be exposed to pile driving noise. We expect early juveniles to seek waters with lower velocity to be able to hold against currents and areas that provides amphipods and aquatic life stages of terrestrial insects such as chironomids (nonbiting midges). YOY do forage over fine sediment such as silt, mud, and sand that support the prey. Thus, given the inside bend location and the fine bottom sediment at the project site, we find it reasonably certain that YOY can be present within the berth area and in waters adjacent to the project site during pile driving.

8.1.4.2 Basic Background on Acoustics and Fish Bioacoustics

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

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

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

The following are commonly used measures of sound:

- Peak sound pressure level (SPL): the maximum sound pressure level (highest level of sound) in a signal measured in dB re 1 μPa.
- Sound exposure level (SEL): the integral of the squared sound pressure over the duration of the pulse (*e.g.*, a full pile driving strike.) SEL is the integration over time of the square of the acoustic pressure in the signal and is thus an indication of the total acoustic energy received by an organism from a particular source (such as pile strikes). Measured in dB re 1μPa2-s.
- Single Strike SEL (ssSEL): the amount of energy in one strike of a pile.
- Cumulative SEL (cSEL): the energy accumulated over multiple strikes. cSEL indicates the full energy to which an animal is exposed during any kind of signal. The rapidity with which the cSEL accumulates depends on the level of the single strike SEL. The actual level of accumulated energy (cSEL) is the logarithmic sum of the total number of single strike SELs. Thus, cSEL (dB) = Single-strike SEL + 10log10(N); where N is the number of strikes.
- Root Mean Square (RMS): the average level of a sound signal over a specific period of time.

8.1.4.3 Criteria for Assessing the Potential for Physiological Effects

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

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

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

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

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

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

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

Halvorsen *et al*. (2012) also conducted studies on the effects of exposure to pile-driving sounds on lake sturgeon, Nile tilapia and hogchoker using a specially designed wave tube. The three species tested were chosen partly because they each have different types of swim bladders. The lake sturgeon, like Atlantic and shortnose sturgeon, has an open (physostomous) swim bladder (connected to the gut via a pneumatic duct); the Nile tilapia has a closed (physoclistous) swim bladder containing a gas gland that provides gas exchange by diffusion to the blood; the hogchoker does not have a swim bladder. Lake sturgeon used in this experiment were 3 to 4 months old and were approximately 60-70 mm in length and weighed 1.2 -2.0 grams (n=141). Tested fish were exposed to five treatments of 960 pile strikes with cSEL ranging from 216 dB re 1µPa2-s to 204 dB re 1µPa2-s. All fish were euthanized after the experiment and examined for internal injury. None of the fish died during the experiment. No lake sturgeon demonstrated any external injuries; internal evaluation showed hematomas on the swim bladder, kidney and intestine and partially deflated swim bladders. Injuries were only observed in lake sturgeon exposed to cSEL greater than 210 dB re 1µPa2-s. All sturgeon were exposed to all 960 pile strikes and only cumulative sound exposure was tested during this study. No behavioral responses are reported in the paper.

Nevertheless, at this time, we consider the FHWG criteria to represent the best available information on the thresholds at which physiological effects to sturgeon are likely to occur. Thus, for the purposes of this Opinion, we consider the potential for physiological effects upon exposure to 206dB re 1 µPa peak and 187 dB re 1 μPa^2-s cSEL. It is important to note that physiological effects may range from minor injuries from which individuals are anticipated to completely recover with no impact to fitness to significant injuries that will lead to death. The severity of injury is related to the distance from the pile being installed and the duration of exposure. The closer to the source and the greater the duration of the exposure, the higher likelihood of significant injury.

8.1.4.4 Available Information for Assessing Behavioral Effects

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

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

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

As hearing generalists, sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005), which does not propagate as far from the sound source as does pressure. However, a clear threshold for particle motion was not provided in the Lovell study. In addition, flanking of the sounds through the substrate may result in higher levels of particle motion at greater distances than would be expected from the non-flanking sounds. Unfortunately, data on particle motion from pile driving is not available at this time, and we are forced to rely on sound pressure level criteria. Although we agree that more research is needed, the studies noted above support the 150 dB re 1 μPa RMS criterion as an indication for when behavioral effects could be expected. With the exception of studies carried out during the Tappan Zee Pile Installation Demonstration Project in the Hudson River, NY, (Krebs *et al*. 2012, 2016), we are not aware of any studies that have considered the behavior of shortnose or Atlantic sturgeon in response to pile driving noise. However, given the available information from studies on other fish species, we consider 150 dB re 1 μPa RMS to be a reasonable estimate of the noise level at which exposure may result in behavioral modifications.

8.1.4.5 Effects of Pile Installation

In general, driving of larger piles generate more sound than driving of smaller piles. However, attenuation rates and sound levels at different distance that sound travel depend on multiple factors. These include the substrate the piles are driven through, water depth surrounding the pile being driven, salinity conditions of surrounding waters, channel dimensions and geometry, obstruction in the path that sound travels that attenuate sound, the method used to drive piles, and any measures implemented during pile driving to attenuate sound (Buehler *et al.* 2015). Bottom topography, underwater structures and landmasses can block, reflect, or diffract sound waves. In addition, there is the potential for refractionary pressure, which results from the pile being struck by the hammer, sound pressure traveling into the substrate, then re-radiating that sound pressure back into the water. It is therefore not possible to predict accurately sound levels at different distances from a pile without first conducting pilot tests at the work site (Buehler *et al.* 2015).

The USACE do not propose conducting pilot tests at the site to provide a more accurate estimate of sound levels during driving of piles during construction. Instead, we rely on data compiled for the California Department of Transportation from tests conducted by others under similar conditions to estimate attenuation rates and the distance at which sound levels would affect sturgeon (Buehler *et al.* 2015).

Based on underwater noise monitoring studies conducted by the Washington State Department of Transportation, the average sound produced during vibratory removal of woodpiles is considerably lower than for vibratory driving of steel piles (WSDOT 2011). We conclude that removal of the woodpiles will not adversely affect sturgeon.

GARFO developed a spreadsheet using proxy projects to assist in estimating sound levels of piles of different types and sizes, driven with different hammers, and with different attenuations[20]. GARFO also developed the Simplified Attenuation Formula (SAF) in order to estimate the ensonification area of pile driving projects in shallow, confined areas, such as rivers. SAF was needed as the Practical Spreading Loss Model (PSLM) is the most accurate for projects in deeper, open water scenarios (*e.g.*, pile driving for wind farms), and tends to greatly overestimate the ensonfication area of pile driving projects in shallower, confined spaces. PSLM also requires an estimate of the number of strikes needed to install a pile (or the number of seconds with a vibratory hammer), and this information is not always available. SAF assumes a constant sound attenuation rate (depending on the type of pile). Attenuation rates were estimated using measurements reported in "Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish," prepared for Caltrans in 2009 (and amended in 2012 and 2015) (http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm). If Caltrans did not include a clear attenuation estimate, GARFO uses 5dB/10m, which we believe to be a conservative estimate because of the likely absorption of sound into the riverbed/seafloor, as well as greater rate at which sound waves attenuate as they get further from the source and cover a wider area (5dB/10m is also representative of the most commonly seen range of attenuation rates in the data presented by Caltrans). Calculation with vibratory pile driving (-10 dB) was done by GARFO. For this Opinion, we use the GARFO spreadsheet and the SAF to estimate sound levels and analyze effects of the proposed pile driving (summarized in Tables below).

Table 8-1 to Table 8-3 provide estimated sound levels and distance from piles where injury and behavioral effects would occur for piles of 24-, 30-, and 36-inch diameter, respectively. As propagation of sound varies and different methods of pile driving affect sound, results for multiple piles are included to better evaluate the risk of adverse effects.

20 The spreadsheet is available at https://www.greateratlantic.fisheries.noaa.gov/protected/section7/guidance/consultation/index.html.

Table 8-1. Proxy Projects for Estimating Underwater Noise (a) and Proxy-Based Estimates for Underwater Noise (b) without bubble curtain. 24" Steel pipe.

a.

Pile	Project Location	Water Depth (m)	Hammer Type	Added Attenuation, dB	Attenuation rate (dB/10m)
A	Martinez, CA - Carquinez Straits	15	Impact	0	5
B	Rodeo, CA - San Francisco Bay, CA	5	Impact	0	3
B	Rodeo, CA - San Francisco Bay, CA	5	Vibratory	-10	3
C	Geyserville - Russian River, CA	0	Impact	0	4
C	Geyserville - Russian River, CA	0	Vibratory	-10	4

b.

Pile	Hammer Type	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})	Distance (m) to 206dB_{Peak} (injury)
A	Impact	207	194	178	12.0
B	Impact	203	189	178	NA
B	Vibratory	193	179	168	NA
C	Impact	197	185	173	NA
C	Vibratory	187	175	163	NA

Table 8-2. Proxy Projects for Estimating Underwater Noise (a) and Proxy-Based Estimates for Underwater Noise (b) without bubble curtain. 30" Steel pipe.

a.

Pile	Project Location	Water Depth (m)	Hammer Type	Added Attenuation, dB	Attenuation rate (dB/10m)
D	Florence, OR - Siuslaw River	3	Impact	0	5
D	Florence, OR - Siuslaw River	3	Vibratory	-10	5
E	San Rafael, CA - San Francisco Bay	4-5	Impact	0	5
E	San Rafael, CA - San Francisco Bay	4-5	Vibratory	-10	5

b.

Pile	Hammer Type	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})	Distance (m) to 206dB_{Peak} (injury)
D	Impact	210	190	177	18.0
D	Vibratory	200	180	167	NA
E	Impact	205	190	180	NA
E	Vibratory	195	180	170	NA

Table 8-3. Proxy Projects for Estimating Underwater Noise (a) and Proxy-Based Estimates for Underwater Noise (b) without bubble curtain. 36" Steel piles.

a.

Pile	Project Location	Water Depth (m)	Hammer Type	Added Attenuation, dB	Attenuation rate (dB/10m)
F	Not Available	<5	Impact	0	5
G	Not Available	10	Impact	0	5
H	Not Available	5	Vibratory	0	5
I	Not Available	5	Vibratory	0	5
J	Eureka, CA - Humboldt Bay	10	Impact	0	3

b.

Pile	Hammer Type	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})	Distance (m) to $206dB_{Peak}$ (injury)
F	Impact	208	190	180	14.0
G	Impact	210	193	183	18.0
H	Vibratory	185	175	175	NA
I	Vibratory	180	170	170	NA
J	Impact	210	193	183	23.3

Based on the data above, measured at a 10 meter distance from the pile, peak sound level reached injury levels for one 30-inch dimeter pile and three 36-inch dimeter piles when driven by impact hammer (Table 8-2:a and Table 8-3:a). Only one of the 24-inch diameter piles generated peak sound pressures expected to cause physiological injury to fish (Table 8-1:a). Only piles driven with impact hammer would be expected to generate peak sound pressure levels above 206 dB re 1 μPa. Water depths ranged from 3 to 15 meters which equals the water depths at the proposed terminal site.

The proposed pile driving will use a vibratory hammer to drive piles the first 70 feet into the substrate. Based on the proxy projects, we do not expect the installation of piles with a vibratory hammer to result in peak noise levels greater than 206 dB re 1 μPa or cSEL greater than 187 dB re 1 μPa^2-s. Thus, there is no potential for physiological effects due to exposure to peak noise levels.

To attenuate noise levels from pile driving by impact hammer, a bubble curtains and a cushion block consisting of multiple layers of plywood approximately 12 inches thick will be used. WSDOT (2006) demonstrated that wood cushion blocks can reduce underwater sound levels by 11 to 26 dB compared to an unattenuated impact hammer if functioning properly. However, Buehler *et al.* (2015) recommended that a specific sound level reduction credit not be taken for the use of cushion blocks because of the limited nature of the WSDOT study, their ability to attenuate noise was highly variable, and because they can splinter or break. Therefore, a bubble curtain would be used in addition to the cushion block. In the biological assessment, the USACE does not specify the type of bubble curtain or equipment that will be used but estimate that a 5 dB attenuation will be achieved.

Thus, based on the information in Table 8-6, a bubble curtain will reduce peak noise levels during driving of the 36-inch diameter from 203 to 205 decibels dB re 1 μPa during pile driving with an impact hammer. We do recognize that the 5 dB reduction is conservative because the cushion block would additionally reduce noise levels by 11 to 26 dB. Because the effect of a wood cushion caps varies, we use the lower end (-11 dB) of measured attenuation in estimating the potential for pile driving exceeding injurious peak noise levels. Based on the use of bubble curtain and wood caps to attenuate noise, we conclude that driving of any of the diameter piles as proposed will not exceed 206 dB re 1 μPa.

In addition to the peak exposure criteria that relate to the energy received from a single pile strike, the potential for injury exists for multiple exposures to noise over a period of time. The cSEL threshold accounts for multiple exposures. The cSEL is a measure of the accumulated energy over a specific period of time (*e.g.*, the period of time it takes to install a pile), rather than an instantaneous maximum noise threshold (Buehler *et al.* 2015). When it is not possible to accurately calculate the distance to the 186 dB cSEL isopleth, we used a calculation of the distance to the 150 dB sSEL isopleth.[21] The greater the distance between the fish and the pile being driven, the greater the number of strikes it must be exposed to in order to be injurious. The threshold distance from the pile indicates that the fish is far enough away that, regardless of the number of strikes it is exposed to, the energy accumulated is not sufficient to cause injury. This distance is where the 150 dB sSEL isopleth occurs (Stadler and Woodbury 2009). A fish located outside of this isopleth has no risk of injury, regardless of the number of pile strikes.

The potential for injury also exists for multiple exposures to noise over a period of time. As described above, we use the 150 dB sSEL isopleth to calculate the threshold distance where the accumulated energy, cSEL, of multiple strikes (or duration during vibratory pile driving) would cause physiological injury. A fish located outside of this isopleth has no risk of injury, regardless of the number of pile strikes.

Using the information from proxy projects and reducing the sSELwith a 5dB attenuation from use of bubble curtain we estimated distances of sSEL of 150 dB during impact driving without and with the use of cushion block (Table 8-4 to Table 8-6). Sturgeon that remain within a distance up to 87 meters (285 feet) of a 24-inch diameter pile or within up to approximately 103.3 meters (339 feet) of a 36-inch diameter pile during impact driving would be exposed to injurious levels of noise during installation of the piles. Again, this is a cautionary estimate since the use of a cushion, if functioning, would further attenuate the noise. It should also be noted that the risk of injury decreases with distance from the pile and a sturgeon closer to a pile would receive less energy over a given time period than a fish close to a pile.

[21] The GARFO developed the Simplified Attenuation Formula (SAF) in order to estimate the ensonification area of pile driving projects in shallow, confined areas, such as rivers. SAF assumes a constant sound attenuation rate (depending on the type of pile). We estimated the distance to the 150 dB re 1uPa sSEL isopleth, using SAF.

Table 8-4. Pile driving of 24" diameter piles. Distance to accumulated energy injury and behavioral disturbance with 16 dB attenuation from bubble curtain (-5 dB) and cushion block (-11 dB) subtracted from dB_{RMS} and $dB_{C}SEL$.

		Proxy-Based Estimates for Underwater Noise		Estimated Distances (m) to Sturgeon/Salmon Injury and Behavioral Thresholds	
Pile	**Hammer Type**	**Estimated Pressure Level (dB_{RMS})**	**Estimated Single Strike Sound Exposure Level (dB_{sSEL})**	**sSEL of 150 dB (surrogate for 187 dBcSEL injury)**	**Behavioral Disturbance Threshold (150 dB_{RMS})**
A	Impact	178	162	34.0	66.0
B	Impact	173	162	50.0	86.7
C	Impact	169	157	32.5	62.5

Table 8-5. Pile driving of 30" diameter piles. Distance to accumulated energy injury and behavioral disturbance with 16 dB attenuation from bubble curtain (-5 dB) and cushion block (-11 dB) subtracted from dB_{RMS} and $dB_{C}SEL$.

		Proxy-Based Estimates for Underwater Noise		Estimated Distances (m) to Sturgeon/Salmon Injury and Behavioral Thresholds	
Pile	**Hammer Type**	**Estimated Pressure Level (dB_{RMS})**	**Estimated Single Strike Sound Exposure Level (dB_{sSEL})**	**sSEL of 150 dB (surrogate for 187 dBcSEL injury)**	**Behavioral Disturbance Threshold (150 dB_{RMS})**
D	Impact	174	161	32.0	58.0
E	Impact	174	164	38.0	58.0

Table 8-6. Pile driving of 36" diameter piles. Distance to accumulated energy injury and behavioral disturbance with 16 dB attenuation from bubble curtain (-5 dB) and cushion block (-11 dB) subtracted from dB_{RMS} and $dB_{C}SEL$.

		Proxy-Based Estimates for Underwater Noise		Estimated Distances (m) to Sturgeon/Salmon Injury and Behavioral Thresholds	
Pile	**Hammer Type**	**Estimated Pressure Level (dB_{RMS})**	**Estimated Single Strike Sound Exposure Level (dB_{sSEL})**	**sSEL of 150 dB (surrogate for 187 dBcSEL injury)**	**Behavioral Disturbance Threshold (150 dB_{RMS})**
F	Impact	174	164	38.0	58.0
G	Impact	177	167	44.0	64.0
J	Impact	177	167	66.7	100.0

Studies on sturgeon behavior towards noise from pile driving in relationship to the construction of the Tappen Zee Bridge over Hudson River found that sturgeon avoid or move out of the ensonified area (Popper 2016). Thus, the sturgeon are expected to avoid an ensonified area upon exposure to underwater noise levels of 150 dB_{RMS}. Behavioral modification (avoidance) is expected between 62 to about 100 meters (203 to 328 feet) depending on piles being driven and depth. Even if a sturgeon is within the ensonified area sSEL of 150 dB when pile driving begins, injury is unlikely because the cSEL injury threshold is cumulative (requiring prolonged exposure to the noise at that level) and sturgeon are expected to leave the area upon the start of pile driving.

We have considered whether a sturgeon is likely to be able to swim far enough away from the pile being installed in time to avoid exposure to the full duration of pile installation. The furthest distances required would be for the 36-inch diameter piles. Assuming pile driving times of approximately ten minutes; a sturgeon would need to swim at least 100 meters before the ten minute pile driving time was completed, requiring a swim speed of approximately 0.17 meter per second to leave the ensonified area. Deslauriers and Kieffer (2012b) measured sustained swimming speed (swimming against a current for 200 minutes) for YOY shortnose sturgeon to 18 m/s. Further, shortnose sturgeon YOY could sustain swimming at velocities of 0.35 m/s for up to 30 to 50 minutes depending on water temperature (Deslauriers and Kieffer 2012a).

Assuming that the sturgeon in the action area have a swimming ability equal to those above, we expect all juvenile shortnose sturgeon and Atlantic sturgeon in the action area to have a prolonged swim speed of at least 0.35 m/s and a sustained speed of 0.18 m/s. Therefore, we expect all sturgeon in the action area to be able to readily swim away from the ensonified area in time to avoid injury.

The cSEL 187 dB re 1μPa^2-s area never occupies the entire width of the river; therefore, there is no danger that a fish would not be able to move out from the area while pile driving is ongoing. Because we do not expect sturgeon to remain close enough to a pile being installed with an impact hammer for long enough to accumulate enough energy to be injured. Further, the use of a reduced energy "soft start"[22] technique would help ensure that sturgeon would be exposed to reduced noise levels for several minutes before the maximum noise levels are reached. A vibratory hammer would be used for the majority of pile driving to further reduce the sound levels. We expect this to cause any sturgeon nearby the pile at the time that pile driving to move further away and reduce the potential for exposure to noise levels that would be potentially injurious or mortal.

Thus, any sturgeon that are present in the area when pile driving begins are expected to leave the area and not be close enough to any pile driving activity for a long enough period of time to experience injuries or mortality. While sturgeon in the area would be temporarily exposed to noise levels while moving out of the ensonfied area, the short term exposure is not likely to result in injuries. Atlantic sturgeon are known to avoid areas with conditions that would cause physiological effects (*e.g.*, low dissolved oxygen, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon would also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that a sturgeon would be exposed to noise levels that could cause major injury or death is if a fish was immediately adjacent to the pile while full strength pile driving was ongoing. Because of the use of the soft start technique

22 The Soft Start procedure for vibratory drivers will be to initiate sound for fifteen seconds at reduced energy followed by a thirty-second waiting period. This procedure will be repeated two additional times. The Soft Start for impact drivers will be to provide an initial set of strikes at reduced energy, followed by a thirty-second waiting period, then two subsequent reduced energy strike sets. Soft Start will be implemented at the start of each day's pile driving and at any time following cessation of pile driving for a period of one hour or longer.

and the expected behavioral response of moving away from the piles being installed, it is extremely unlikely that sturgeon will be exposed to noise levels for long enough time to cause injury. Effects from sound pressure waves generated during pile driving are therefore discountable.

8.1.4.6 Behavioral Effects from Pile Driving

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

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

Depending on the pile size being driven, the 150 dB re 1 μPa RMS isopleth (radius) would extend from 80 to 130 meters (263 to 427 ft.) from the pile being driven. Shortnose sturgeon and Atlantic sturgeon in the area where piles are being installed are likely to be foraging (in areas where suitable forage is present), resting, or migrating to upriver or downriver areas. We consider two scenarios here; (1) sturgeon that are near the pile being installed and must swim away from the pile to move out of the area where noise is greater than 150 dB re 1μPa RMS; and, (2) sturgeon that are outside of the area where noise is greater than 150 dB re 1μPa RMS at the onset of pile driving but then would avoid this area when pile driving was ongoing.

In the first scenario, sturgeon exposed to noise greater than 150 dB re 1μPa RMS are expected to have their foraging, resting or migrating behaviors disrupted as they move away from the ensonified area. Even at a slow prolonged speed of 1.1 fps, all sturgeon would be able to swim out of the area where noise is 150 dB re 1uPa RMS within 30 minutes (in the worst case, swimming through the longest cross section of 1,772 feet). Thus, any disruption to normal behaviors would last for no longer than 30 minutes. Foraging is expected to resume as soon as a sturgeon leaves the area. Resting and migrating would also continue as soon as the individual had moved away from the disturbing level of noise. It is unlikely that a short-term (in the worst case no more than 30 minutes, and generally much shorter) disruption of foraging, resting or migrating would have any impact on the health of any individual sturgeon. Also, because we expect these movements to occur at normal prolonged swim speeds, we do not expect there to be any decrease in fitness or other negative consequence.

Pile driving will never occur for more than 12 hours a day but in the worst case, fish would avoid the ensonified area (i.e., the project site) for the entirety of the pile driving period. The Delaware River at the project site is approximately 920 meters (3,020 ft.) wide from the bank of the old bulkhead to the banks of Little Tinicum Island. A shallower secondary channel exists on the

Pennsylvania side of the island. The wharf platform would extend approximately 30 meters (98 ft.) waterward. Thus, the behavioral disturbance at the ensonified area will extend a maximum of 160 meters (535 ft) into the channel. At all times, there will be at least 760 meters (~2495 ft.) of the river width with pile driving generated noise levels less than 150 dB re 1uPa RMS. Therefore, it is likely that any sturgeon that was not close to the pile at the time installation began, would be able to completely avoid the area where noise was greater than 150 dB re 1uPa RMS. Assuming the worst case behaviorally, that sturgeon would avoid an area with underwater noise greater than 150 dB re 1 µPa, there would still always be a significant area where fish could pass through unimpeded.

Pile driving activities may cause sturgeon near the construction area to move into the navigation channel, where there is an increased risk of interaction with vessels. The proposed berth construction activities are located approximately 245 meters (810 ft) from the Federal navigation channel. With noise levels expected to modify behavior extending a maximum of 160 meters into the channel, there are ample clearances to avoid elevated noise areas without entering the navigation channel. Further, the time of year restrictions for in-water work means that adult sturgeon would not be migrating through the construction area to the spawning locations during the pile-driving.

Based on this analysis, we have determined that any minor changes in behavior resulting from exposure to increased underwater noise associated with pile installation will not preclude any shortnose or Atlantic sturgeon from completing any normal behaviors such as resting, foraging or migrating or that the fitness of any individuals will be affected. Additionally, there is not expected to be any increase in energy expenditure that has any detectable effect on the physiology of any individuals or any future effect on growth, reproduction, or general health. Therefore, effects from behavioral responses to pile driving noise, if any, would be so small we cannot meaningfully measure, detect, or evaluate them; effects are insignificant.

8.1.5 *Effects of Construction Vessel Traffic*

Construction activities would temporarily increase vessel traffic in the action area, which in turn could increase the risk of sturgeon interactions with vessels. The objective of this section is to evaluate the effects of vessel traffic from construction and dredging activities on sturgeon. Effects from traffic during operation of the marine terminal is discussed in section 8.2.4.

Both Atlantic sturgeon and shortnose sturgeon are killed by vessel strikes annually in the Delaware River as described in section 6.3.3.3. Most sturgeon vessel mortalities have been attributed to large commercial vessels (Balazik *et al.* 2012b, Brown and Murphy 2010). However, tug boats, barges, and towboats can strike and kill sturgeon as has been documented in the Mississippi River (Gutreuter *et al.* 2003, Killgore *et al.* 2011). A tugboat vessel strike and mortality has also been observed in the Delaware River. In 2016, a tugboat moving about 11 knots was observed striking and killing a gravid adult Atlantic sturgeon female in the Federal navigation channel (Ian Park DENRC, personal communication, June 2017).

The relative importance of different factors relevant to determining the risk to sturgeon injury and mortality from vessel strikes are currently unknown. However, 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, size of the fish, and the behavior of sturgeon in the area (*e.g.*, foraging, migrating, etc.) affect risk of interaction with the hull of a vessel or entrained through a vessel's propeller

(Balazik *et al.* 2012b, Brown and Murphy 2010, Fisher 2011, Hondorp *et al.* 2017, Killgore *et al.* 2001, Killgore *et al.* 2011, Miranda and Killgore 2013).

Entrainment of an organism means that a water current (in this case created by the propeller) carries the organism along at or near the velocity of the current without the organism being able to overcome or escape the current. Thus, as the boat propeller draws water through the propeller, it also consequently entrains the organism in that water. We assume that larger propellers are more likely to entrain a sturgeon since large diameter propellers have a larger area of influence and entrain more water. Vessels with deep draft or where the draft relative to the depth is small may also be more likely to strike sturgeon as sturgeon may spend over 90 percent of the time on or near the riverbed (Cameron 2012). The faster that a vessel is traveling may also increase the chance that a vessel will strike a sturgeon as the fish will have a shorter time to detect, respond, and avoid an approaching vessel especially for shallow draft vessels encountering a sturgeon higher in the water column. Adult sturgeon migrating to or from spawning sites seem to be more vulnerable to vessel strike (Balazik 2012, Brown and Murphy 2010). This may be because sturgeon may move higher in the water column and use navigation channels during spawning migrations (Hondorp 2017). It may also be that the larger adults are more prone to vessel strike since most reported vessel mortalities have been larger individuals (Balazik 2012, Brown and Murphy 2010) though it may also be the case that dead smaller individuals are less likely to be found and/or reported. All things being equal, we assume that the density of vessels on the river will determine the risk of vessel strikes; that is, we assume that the risk of strike of any given individual sturgeon in an area increases proportionally with an increase in the number of vessels in that particular area. A median of more than 40,000 registered vessel trips occur annually in the Delaware River. As explained in section 6.3.3, based on that number of vessels and the estimated number of sturgeon killed by vessel strike in the Delaware River, there is approximately one Atlantic sturgeon killed for every 883 vessel trips, with the number of shortnose sturgeon killed being apparently lower (see section 6.3.3). Thus, despite being one of the primary known sources of direct anthropogenic mortality to sturgeon in the Delaware River, the probability of any particular vessel striking a sturgeon is extremely small.

Based upon the applicant's project schedule, vessel traffic associated with berth dredging and pile installation would not be active within the construction area after April 1, 2018. Dredging and pile driving and, therefore, associated vessel activity will occur from December 2017 to April 1, 2018. In the Delaware River, spawning by Atlantic sturgeon starts in mid-April and may continue through July. Adult and subadult Atlantic sturgeon may be present during that period, although most subadult and adult Atlantic sturgeon are expected to have moved into downstream estuarine waters with higher salinity, into the bay, or migrated into marine waters in late fall (about November) and therefore, not be present in the project area during construction. We expect subadult Atlantic sturgeon, adult shortnose sturgeon and juveniles of both species to be present year round.

Vessel activity related to these project development activities will not occur during the period of time when adult Atlantic sturgeon are expected to occur in the river, including the spawning period. This will minimize the risk of vessel strikes as a large percentage of reported vessel mortality occur during the spawning season.

Dredging would involve tugboats, a crew boat, dredging barge, hopper and decant barges within the dredging area. Such vessels have an average propeller diameter of 2.5 meters and travel at an approximate speed of less than ten knots (Miranda 2013). While the propeller diameter is substantially larger than for recreational vessels (normally less than 0.5 meter diameter), the propeller is substantially smaller than for large commercial cargo and tanker vessels (may have propellers that approach 10 meters in diameter).

The USACE state that all vessels used during dredging and construction of the terminal platforms will have a draft of 1.8 meters (6 ft.) or less with the exception of Hopper/Decant Barges that have a 2.7-meter (9 feet) draft. During transport of piles and sediment, these vessels will operate in the Federal Navigation Channel which has a depth of 13.7 meters (45 feet). Water depth in the majority of the 27-acre construction area is 11 meter (35 feet) MLW and will be dredged to 12.2 meters (40 feet); therefore, construction vessels would have a minimum draft clearance of 34 feet when moving within the construction area. Thus, there are ample clearance between the hull of the vessels and the riverbed and the risk of interaction is substantially less than for other larger vessels operating on the Delaware River.

Project construction and dredging vessels will be present within the action area as they transit to/from the berth. However, the majority of vessel transit would occur within the Federal navigation channel between the berth at RKM 139.2 (RM 86) and identified dredged material disposal sites at Whites Basin (RKM 132, RM 82), Fort Mifflin (RKM 147.3, RM 91.5), and Weeks Marine (RKM 161.7, RM 100.5). Approximately two decant barges would be in use, but they would generally be stationary in the dredging area. Approximately four hopper barges are expected to be used for the dredging operations, each with a capacity of 2,500-3,000 cy. Daily maximum dredging volumes are estimated to be 10,000 cy per day; therefore, it is estimated that a maximum of approximately eight barge trips per day would be needed for dredging. Each barge (no propeller) is pushed by a single tugboat and dredge barge trips include the barge and tugboat together. Based on the maximum volume of dredged material to be transported from the dredging area to the disposal areas via barge, dredging would require no more than 300 barge trips over a five month period. If hydraulic dredging is used, the material would be disposed of via a pipeline reducing barge traffic by approximately one third. Vessels travelling to a disposal facility would travel within the Federal navigation channel and between the channel and the facility disposal site. The distance from the Federal navigation channel and disposal facilities is small (*e.g.* less than 500 feet at Fort Mifflin) and, therefore, vessel traffic associated with dredged material disposal would occur predominantly within the Federal navigation channel. Assuming that barges transporting dredged material disposal would travel at speeds less than 10 knots, the average travel time in the Federal navigation channel between the disposal or processing sites would be between 0.3 hours and 1.2 hours as summarized in Table 8-7

Table 8-7. Vessel Destinations for the Management of Dredged Material.

Destination	Location (RKM/RM)	Approximate Time of Travel (hours)	Maximum Number of Barge Trips
Whites Basin	132/82	0.3	120
Ft. Mifflin	147.3/91.5	0.4	120
Weeks Marine Camden Facility	161.7/100.5	1.2	58

Berth construction and pile driving would require 2 tugboats, 2 work barges, 1 crew boat, and 1 delivery boat. The use of construction vessels would result in a localized, temporary increase in vessel traffic during the project period. Construction vessels used for berth construction and installation would use the Federal navigation channel when traveling to and from the berth. Assuming the carrying capacity of a delivery boat is roughly 40 piles, there would be approximately 20 one-way vessel trips required to transport the 384 piles necessary for the berth construction over 2.5 months. This is equivalent to an average of less than 2 vessel trips per week. Delivery vessels would be transiting from the Weeks Marine Camden facility. Assuming that the delivery boat travels at a speed of less than 10 knots, average travel time in the Federal navigation channel between Weeks Marine in Camden and the berth is approximately 1.2 hours. Concrete materials would be delivered from the landside and would not increase vessel traffic.

Vessel trips associated with construction, pile driving, and dredging could cause a temporary increase of 1.4 vessel trips per day over 7.5 months. The majority of vessel transit would occur within the Federal navigation channel. Commercial vessel traffic in the Federal navigational channel between Philadelphia, PA and the downstream end of the action area is 51,547 vessel trips (USACE 2017b), or approximately 141 vessel trips per day. An increase of 1.4 vessel trips per day is approximately 1% of daily traffic within the Federal navigation channel.

Considering the timing of vessel activity, the type and draft of vessels, the small number of project vessels we find that the increase in risk of vessel strike when adding the project vessels to baseline is so small that it cannot be meaningfully measured, detected or evaluated. Therefore, effects from vessels during dredging and construction vessel traffic are insignificant.

8.2 Effects of Interrelated and Interdependent Activities

Interrelated activities are defined as actions that are part of the proposed marine terminal and depend on the proposed marine terminal for their justification. An interdependent activity is defined as an activity that has no independent utility apart from the action. The objective of this section is to evaluate the effects of the proposed facility operations on sturgeon, including vessel ballasting, noise from the marine terminal operations, and vessel traffic. This section also considers the effects of mitigation activities and the construction and operations of upland marine facilities. Effects of these activities on all life stages of sturgeon present in the action area are considered.

8.2.1 *Risk of Liquid Energy Products Spills*

The proposed action includes the loading and shipping of crude oil and other liquid energy products. Incidents during both transport and on-/off-loading have the potential to result in spills of petroleum products and chemicals. Large spills of petroleum products can pose significant environmental damage. Petroleum and chemical products from vessels disrupt egg and larvae development, impact benthic habitat and reduce abundance of benthic invertebrates, and can disrupt spawning.

Between 1974 and 2010, there were at least 27 larger spills in the Delaware River and Delaware Bay (Delaware River and Bay Oil Spill Advisory Committee 2010). Last major oil spill in the Delaware River was in 2004 when the single hull tanker Athos 1 unknowingly struck a large anchor submerged in the Delaware River while preparing to dock at a refinery just outside Philadelphia, Pennsylvania. However, given the annually large number of cargo and tanker activity on the Delaware River and in the Delaware Bay (31,114 in- and outbound trips in 2015), the risk of major oil spills is relatively low. The proposed marine terminal will handle up to 133 vessels at the proposed marine terminal per year. Of these, approximately 31 vessels will carry liquid energy products that are expected to be redistributed from other terminals and will not result in an increase in tanker vessels on the Delaware River of in the Delaware Bay. The proposed marine terminal will increase vessel trips on the Federal Navigation Channel with approximately 182 up- and downbound RoRo vessel trips. Thus, the increase in vessel activity, and consequently risk of accidents causing spills, when added to baseline vessel activity is extremely small.

As described in the proposed action, the applicant has a comprehensive oil spill contingency plan in place for the loading and shipping of crude oil. Although there is a risk of a spill occurring, we do not expect a spill to occur in the foreseeable future because of the oil spill contingency plan put in place by the applicant. The Applicant has oil spill contingency plans with the EPA, USCG, and NJDEP that cover potential spills in the Delaware River. These plans contains several measures, as outlined in Section 3.7.3, to minimize the risk of a spill to happen, to ensure that facilities have adequate oil spill response capabilities, and to prevent uncontrolled discharges of oil beyond the limits of the marine terminal. For these reasons, we do not consider a spill as reasonably certain to occur. We do not consider impacts from a spill to be effects of the action for the purposes of this analysis.

8.2.2 *Effect of Ballast Water Intake*

Ballast water is water carried in ships' ballast tanks to maintain stability. During offloading of cargo at the berth, vessels may withdraw water from the surrounding environment to supply to the ballast tanks for proper operations and stability. Ballast water intakes would not be expected to operate continuously but would only be active for short periods of time during the loading and unloading process. Ballast water intake openings are screened to minimize the intake and release of debris and aquatic life. Based on information provided in the biological assessment for the proposed marine terminal, typical screens on ballast intakes are approximately 10 mm.

Intake of ballast water can directly affect fish by entraining or impinging on the screen mobile and immobile (eggs and larvae) lifestages of fish. The discharge of ballast water may release marine invasive species into the riverine environment, which has the potential to negatively affect native benthic organisms and fish communities.

Entrainment and Impingement

Passive floating eggs and ichthyoplankton entrained will be directly related to the location of the life stage relative to the intake, the density of these life stages in the water column, and the volume of water taken in as ballast. The risk of ballast intake entraining mobile life stages depends on the pumping rate, the direction and velocity of river currents near the intake (dependent on tidal cycle), and the size of the fish. A fish is susceptible to being entrained or impinged at the ballast intake if velocities at the intake carries the sturgeon along at or near the velocity of the current without the organism being able to overcome or escape the current. Smaller fish can become transported through intake screens and into the ballast tank due to size or body orientation when they encounter the intake. Fish too large to be transported through the screens of the intake may become impinged if captured sidelong across the intake. Vessels evaluated in this Opinion may seek port at the proposed terminal at any time of the year. Therefore, all life stages of Atlantic sturgeon may be exposed to the vessels' intake of ballast water. Shortnose sturgeon spawn more than 40 miles upriver of the action area. Therefore, no shortnose sturgeon eggs or yolk sac larvae are expected to be present in the action area during ballasting operations.

The ability of sturgeon to escape entrainment depends on their swimming speed and performance. Typical critical swimming speeds (<20 seconds) measured for sturgeon range between 22 cm/s to 105 cm/s (Prakash *et al.* 2014, Verhille *et al.* 2014). Deslauriers and Kieffer (2012b) measured mean critical swimming speed of shortnose sturgeon 7.1 cm TL to 22.30 cm/s and for fish 19.4 cm TL to 29.5 cm/s. Limited information is available about the swimming speeds for Atlantic sturgeon. Verhille *et al.* (2014) summarized literature of critical swimming speeds for various sturgeon species. For all *Acipenser* spp. listed in the paper but not including shortnose sturgeon, U_{crit} for sturgeon between 4 and 8 cm TL ranged from 25.2 to 43.3 cm/s, U_{crit} for sturgeon between 10 and 30 cm TL ranged from 36 to 64.2 cm/s, U_{crit} for sturgeon 30 cm TL and longer ranged from 44.9 to 106.3 cm/s. Based on the above, we consider both Atlantic sturgeon and shortnose sturgeon larvae and small juveniles able to escape near field velocities of 22.3 cm/s and for sturgeon larger than 20 cm TL to escape velocities of 30 cm/s. Juveniles larger than 30 cm TL and adults are able to escape velocities of 50 cm/s.

Prakash *et al*. (2014) used a 3-dimensional model to develop a zone of influence to determine the ability of mobile fish life stages to avoid impingement for LNG vessels at Crown Landing terminal in the Delaware River. The zone of influence was calculated to approximately 5 m–6 m in the vertical directions and about 50 m in the horizontal direction. When the vessel is takin in ballast, the hydrodynamics close to the intake is mostly dominated by the intake momentum compared to the tidal influence with the mouth of the intake experiences intake velocities of 30–50 cm/s. A small area of 13 m^3 was above the burst swimming speed of 40 cm/s. The influence and velocity rapidly decreased with distance from the intake. Close to the bottom (at a distance of 6m), velocities ranged from 0.5 to 6 cm/s while at around 50 m in the horizontal direction from the intake level, the difference in net velocity magnitude drops to 0.1% (<0.5 cm/s as compared to 50 cm/s at the intake cell). Vessels types transporting RoRo cargo have ballast pumping rate requirement that is lower than for a typical LNG vessel (USACE 2017).

Sturgeon spawn their eggs over hard bottom substrate where the eggs attach to the substrate and hatchlings quickly find cover in nearby substrate. Further, post yolk sac larvae drift in the water column one meter above the bottom in deep sections of the river channel and become demersal once they settle. Similarly, juveniles less than 30 cm TL will be expected to be mostly on the bottom foraging in deep portions of the river. We also expect sturgeon to generally avoid the berth area because of vessel activity and low quality forage from sediment disturbance. Ballast intakes are also not located near the bottom of a vessel's hull but further up on its side (*e.g.*, in Prakash *et al.* (2014) model of a LNG tanker, the ballast intake was 3.7 m above the keel). Thus, eggs, larvae, and smaller juveniles are extremely unlikely to be exposed to hydraulic forces that would entrain them in the ballast intake when the vessels are docked at the terminal. Effects to eggs and larvae are discountable.

Larger juveniles and adults of both species as well as subadult Atlantic sturgeon are similarly expected to not utilize the berth area because of disturbance and degraded foraging but may move higher in the water column and closer to the vessels than smaller sturgeon during seasonal movements and spawning migrations. The highest intake velocities (velocities of 30–50 cm/s) occur at the mouth of the intake and larger sturgeon may be exposed to these higher velocities. It should be noted that the sturgeon have to be next to the intake to experience the higher flow velocities. However, the velocities at the intake when the ballast water intake is active are within the mean burst swimming speeds of both Atlantic and shortnose sturgeon. Therefore, we expect sturgeon over 30 cm TL to be able to escape entrainment in the water current and avoid impingement. It is therefore extremely unlikely that a 30-cm long or larger sturgeon would be entrained or impinged at the intake and effects on sturgeon from pumping of ballast water are discountable.

Non-native species

Ballasting operations vary by vessel type and operations. Ballast water may be taken up or discharged when cargo is unloaded or loaded, or when a ship requires additional stability in foul weather. Commonly, vessels release ballast water to lighten the vessel and decrease draft when entering shallow shipping channels. For vessels entering the Delaware River navigation channel, discharge of ballast may occur at sea before entering the channel or at one of the anchorage areas. While all cargo vessels use ballast water for stabilization, particularly in heavy sea conditions, modern cargo vessels include design features that enable them to re-use ballast water internal to the ship by pumping ballast water from one internal tank to another (USACE 2013b). This management effort reduces the reliance on external water sources and the problems it poses.

The USACE states in the biological assessment that the Applicant will comply with the USCG ballast water regulations pertaining to ballast water exchange (33 CFR 151.1510). The ballast water exchange regulations require international ships to: (1) conduct mid-ocean ballast exchanges more than 200 miles off-shore, (2) retain ballast water, or (3) use an approved ballast water management system (BWMS) that meets USCG discharge standards relative to organism content. The BWMS is any system which processes ballast water to kill, render harmless, or remove organisms. In addition, USEPA regulates incidental discharges into waters of the United States from commercial vessels greater than 79 feet in length and for ballast water from commercial vessels of all sizes through the Vessel General Permit program.

Vessels calling at the proposed marine terminal would be required by law to abide by USCG regulations in order to avoid adverse effects of invasive species that may be present in ballast water, and to minimize intake of larvae and juvenile fish. Based on these regulations, the majority of all ballast water exchanges for vessels calling on the proposed terminal will occur in off-shore marine waters. While at berth, the Applicant will require that the discharge and intake of ballast water is limited to the minimum needed to assure vessel stability.

As described in Section 3.7.4, it is estimated that RoRo vessel traffic would be new traffic, and traffic associated with carriers of break-bulk, crude oil, refined products and liquid gases would be diverted from other Delaware River Ports (Table 3-6). Of the 133 vessels expected to call on the proposed facility annually, no more than 91 would represent vessels that were not already transiting to existing ports on the Delaware River. Only ballasting from the RoRo vessels would constitute an addition to baseline conditions, since the other vessels would be ballasting within the Delaware River even if the proposed marine terminal is not developed.

8.2.3 *Effects of Noise*

Noise from operations of the proposed facility could adversely impact sturgeon if noise levels exceed the behavior and physiological thresholds identified in Section 8.1.4. Effects of noise from vessel traffic from marine terminal Operation is discussed at below.

Several sources of ambient noise are present in the waters surrounding the port, including noise from recreational and commercial vessels in the Federal navigation channel, operational noise from adjacent industrial facilities and the Philadelphia International Airport located across the River. Noise associated with operation of the proposed marine terminal may be associated with slow-moving vessels or occasional operation of a crane and other equipment. Noise monitoring at the Port of Vancouver in Vancouver, Washington indicates that ambient sound levels associated with facility operations range from 60-75 dB on average (VFPA). The Port of Vancouver handles a range of cargo and facilities similar to the proposed marine terminal, including break bulk and RoRo. With five terminals and 13 berths, the Port of Vancouver is much larger and busier than the proposed marine terminal; therefore the anticipated operational noise levels for this project are expected to be below 75 dB. Therefore, noise associated with project operations would not result in a significant increase in noise levels above baseline and would not exceed the injury or behavioral threshold for impacts to sturgeon. No effects to sturgeon are expected due to noise from facility operations.

8.2.4 *Effects of Vessel Traffic from Marine Terminal Operation*

Vessels moving over a body of water can injure or kill aquatic species by vessel collision causing blunt trauma, by the propeller striking the animal, or by water drawn through the propeller entraining aquatic organisms. Observations of vessels strikes killing or injuring sturgeon have been reported (*e.g.* Ian Park, personal communication, 2017) and examinations of sturgeon carcasses indicate that vessel strikes caused many of the mortalities (Balazik *et al.* 2012b, Brown and Murphy 2010; also, see discussion in previous sections of this Opinion).

The timing and location of vessel traffic in the action area also may influence the risk of a vessel striking a sturgeon. Sturgeon are migratory species that travel from marine waters to natal rivers to spawn. A significant increase in vessel traffic during the spawning period could potentially increase the risk of vessel strike for migrating adult sturgeon. Similarly, narrow channels or passageways with restricted clearance may increase the probability that sturgeon will be struck and killed by a vessel.

The operation of the proposed marine terminal is expected to increase vessel traffic at the berth and on the Federal Navigational Channel. Both project and shipping vessel activities could result in the vessels colliding with or the propellers striking listed species. Here we review what we know about vessel-species interactions and the factors contributing to such interactions, and analyze the effects of the proposed marine terminal on ESA-listed sturgeon.

8.2.4.1 Vessel Activity at the Marine Terminal

When the proposed marine terminal operates, it is expected to increase vessel traffic between the berth and Federal Navigational Channel above baseline conditions. The existing berths have not been used since the early 1990s. The marine terminal will consist of a single berth and each vessel requires approximately two days in port. Consequently, the proposed marine terminal is expected to have 133 vessel calls per year (266 vessel trips), or approximately 2.75 vessel calls per week. At a projected 133 vessels per year, the terminal is at maximum capacity and the number of vessels to call on the marine terminal in any given year will not increase over the lifetime of the facility. Vessels will access the terminal from the Federal Navigation Channel.

When moving between the proposed marine terminal and the Federal navigation channel, vessel maneuvering speeds likely would be in the range of 2 to 5 knots. The speed of the vessel when turning is primarily a function of maneuverability and will depend on the size of the vessel, turning radius, and angle of approach. Based on these factors, vessel speeds in the turning area are generally not expected to exceed 5 knots. When traveling to and from the proposed marine terminal, a single slow-moving vessel would be moved between the Federal Navigational Channel and a single-berth over a distance of 275 meters (900 feet). Vessels maneuvering within the berth would have a minimum of 0.31-meter (1 foot) clearance from the bottom surface. The actual clearance may be greater, depending on the draft of a particular vessel.

Habitat Modification by Vessel Operations in the Berth

The Shortnose Sturgeon Status Review Team (SSSRT 2010) and the Atlantic Sturgeon Status Review Team (ASSRT 2007) bot have identified loss of habitat as a threat to sturgeon in the Delaware River. Loss of foraging habitat and limitation of forage can increase competition for food, decrease growth rate, increase time to maturity or inter-spawning periods, and decrease egg production.

Vessels maneuvering in shallow waters can result in major erosion of the riverbed and suspension of sediment. Erosion of the riverbed and resuspension of sediment will affect the composition, density, and availability of benthic invertebrates (Gabel 2012). The strong swirling jet flow induced by a rotating ship propeller causes shear stress and can scour the riverbed (Karaki and van Hoften 1975, Hong *et al*. 2013, 2016). Because the propeller-induced bed shear stress is a main stirring force, sediment erosion, resuspension and deposition are all expected to be closely related to vessels maneuvering while docking (Karaki and van Hoften 1975). Vessel activity also creates waves that erode the shoreline and causes drawdown that resuspend sediment in shallow near shore areas. Sediment resuspension is one of the main processes that affects the amount of suspended sediment transport and affects sediment concentrations in the water column. The sediment plume is influenced by the direction and speed of the river current. The re-suspension can also contribute to transport of contaminants from a polluted area to a non-polluted area. Studies have also shown that scouring and resuspension of sediment caused by vessel traffic negatively affect submerged aquatic vegetation (Asplund and Cook 1997).

Several theoretical models and empirical methods to calculate amount of scour and sediment transport caused by propeller shear stress and jet propulsion have been developed (*e.g.*, Hong 2016, Absalonsen 2014, Nybakk 2015). However, the USACE have not provided any analysis of effects from operation of the terminal and we cannot quantify the amount of sediment resuspended, expected TSS by a single vessel docking at the proposed terminal, or the direction and extent of the sediment plume given that it depends on a variety of factors, including but not limited to tidal fluctuations, turbulence dynamics of the river reach, salinity layers, possibly the density of vessel traffic. Nevertheless, studies of berthing areas and docks show that vessels maneuvering at docks commonly result in substantial scouring the riverbed and increased total suspended sediment in the water column. The vessels docking at the proposed terminal will have large sized propellers, dock at a frequency of about one vessel every other day, and have a draft clearance of less than a meter at the docking site. Therefore, we are reasonably certain that operation of the terminal will result in continuous disturbance of sediment, submerged aquatic vegetation, and the density and composition of benthic invertebrates. Both tests of sediment in the berthing area and baseline conditions show that sediment in the river contains high levels of contaminants (USACE 2017). Based on high background contaminant levels in sediments of the Delaware River, suspended sediment would likely contain contaminants. Further, vessel activity and propeller motion when vessels are arriving and leaving the berth are likely to disturb sturgeon that are present within or adjacent to the berth area. Based on these considerations, we conclude that the operation of the terminal will result in a permanent degradation of sturgeon foraging habitat within the berth area.

The proposed terminal berthing area is approximately 27 acres, including the platform structure. This area represents just a small fraction of the action area but it will add to baseline disturbance from other activities. The Federal Navigation Channel may require an annual maintenance dredging of approximately 588 acres of shoals made fine sediment and silt below RKM 107.8, or the downstream median range of the salt front, and RKM 78 (NMFS 2017b). This area is approximately 10 kilometers downstream from the project site and represents approximately 2.6 percent of potential foraging habitat within that reach of the river (NMFS 2017b). Vessel disturbance may also negatively affects a large, but unquantified, portion of the river's potential foraging habitat. In 2014, we consulted with the USACE on a 10-year permit to the Weeks Marine Inc. for maintenance dredging of 31 ports in the Delaware River and Schuykill River for a total of 511 acres. Besides intermittent but regular dredging of these ports, vessel impacts on the habitat are expected to similarly degrade the habitat for use by sturgeon. Additional smaller docks and ports exists throughout the action area. The semi-enclosed Weeks Marine Inc. Whites basin used for dredge material disposal and handling is located approximately three miles downstream from the project site. This constant disturbance of this site and its semi-enclosement render the site unusable for sturgeon foraging. Still, the up to 2 km wide tidal Delaware River provides large areas with soft substrate that can support benthic invertebrates, and adding the berth area to baseline will result in an extremely small change to available soft substrate foraging habitat. Areas with fine material substrate occur in the river channel immediately upstream and downstream of the project site. Given the small area and availability of similar habitat nearby, we conclude that the loss of foraging habitat within the berth area will result in effects to any life stage of either sturgeon species that are so small that we cannot meaningfully measure, detect, or evaluate them; effects are insignificant.

8.2.4.2 Vessel Traffic on the Federal Navigation Channel

As described in Section 3.7.4 it is estimated that RoRo vessel traffic would be new traffic, and traffic associated with carriers of break-bulk, crude oil, refined products and liquid gases would be diverted from other Delaware River Ports (Table 3-6). The biological assessment identifies that tanker vessels may be redistributed from two refineries upstream of and two downstream of the proposed marine terminal. Break bulk may be redistributed from the Port of Wilmington downstream of the proposed marine terminal or from the Penn Terminal across the river from the proposed marine terminal. Multiple factors, including but not limited to demand and capacity at the terminals at any one time, determines where vessels will seek port. Consequently, we cannot with reasonable certainty determine the number of vessels that will be redistributed from upstream terminals or downstream terminals. Therefore, we assume that the operation of the proposed marine terminal will not result in any net increase or decrease in number of vessels in any reach of the Delaware River. As stated, the USACE estimates that of the 133 vessels expected to call on the proposed marine terminal annually, no more than 91 would represent vessels that were not already transiting to existing ports on the Delaware River. We take this to mean that the operation of the proposed terminal will result in a reduced activity at existing terminals equal to 42 vessels and that exiting terminals will not compensate the loss of business by having other ships replacing vessels diverted to the proposed marine terminal once in operation. In other words, the proposed terminal will only increase the number of vessels using the Federal Navigation Channel with 91 vessels or 182 trips (i.e. 91 to and 91 from terminal) over baseline use. This equals to adding an average of one vessel trip (upstream or downstream) to existing vessel traffic every two days.

8.2.4.3 Factors Relevant to Vessel Strike

Factors relevant to determining the risk to Atlantic and shortnose sturgeon from vessel strikes include, but may not be limited to, the 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 size and 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.

A moving vessel can cause injury or death to a sturgeon by the hull striking the sturgeon, the propeller striking the sturgeon, or the sturgeon becoming entrained through the propeller. We assume that the chance of injury and death increases with the vessel's speed and mass but we do not know at what speed mortality would occur for different types of vessels or for different sizes of sturgeon.

Entrainment of an organism means that a water current (in this case created by the propeller) carries the organism along at or near the velocity of the current without the organism being able to overcome or escape the current. Thus, as the boat propeller draws water through the propeller, it also consequently entrains the organism in that water. The risk of entrainment is likely to be highest for smaller sturgeon, which have decreased swimming ability and burst escape speed compared to larger individuals, and for larger vessels, which will entrain more water and may entrain that water at a higher velocity.

Propeller engines work by creating a low-pressure area immediately in front of the propeller and a high pressure behind. In the process the propeller moves water at high velocities (can exceed 6 m/s) through the propeller. Fish that cannot avoid a passing vessel, that are entrained by the propeller current, and who are unable to escape the low-pressure area in front of the propeller will be entrained through the propeller. Thus, whether a fish is able to avoid entrainment depends on its location relative to the force and velocity of the water moved by the propeller and its swimming ability relative to those forces.

Larger propellers draw larger volumes of water, and we therefore expect the likelihood of a propeller entraining a fish to increase with propeller size. Recreational vessels rarely have propellers exceeding 0.5 meter in diameter, towboats and tugs commonly have propellers between two and three meters in diameter, and tankers and bulk carrier vessels with a 40-foot draft may have propellers that are seven to eight meters in diameter. Commonly, all vessel types may have two propellers. Larger vessels such as tankers and cargo vessels have occasionally three propellers. Thus, we expect large tugboats, cargo vessels, and tankers to have a substantial larger area of influence than recreational or smaller fishing vessels.

Not all fish entrained by a propeller will necessarily be injured or killed. Killgore *et al.* (2011) in a study of fish entrained in the propeller wash (two four-blade propellers that were 2.77 meters in diameter) from a towboat in the Mississippi River found that 2.4 percent of all fish entrained and 30 percent of shovelnose sturgeon entrained showed direct sign of propeller injury (only estimated for specimens ≥12.5 cm TL). The most common injury was a severed body, severed head, and lacerations. This is consistent with injuries reported for sturgeon carcasses in the Delaware River and James River (Balazik *et al.* 2012b, Brown and Murphy 2010).

Killgore *et al.* (2011) found that the probability of propeller-induced injury (i.e. that the propeller would contact an entrained fish) depends on the propellers revolution per minute (RPM) and the length of the fish. Simply put, the faster the propeller revolves around its axis, the less time a fish has available to move through the propeller without having a blade hitting it. Similarly, the longer the fish is, the longer time it would need to move through the propeller, thereby increasing the chance that a propeller blade hits it. The injury probability model developed by Killgore *et al.* (2011) showed a sigmoid (or "S" shaped) relationship between fish length and injury rate at a given RPM. The model estimated probability of injury at about 150 RPM for the towboat in their study increased from 1% for a 12.5-cm fish to 5% for a 35-cm long fish, and from 50% for a 72-cm long fish to 80% for a 90-cm long fish. However, Killgore *et al.* (2011) did not find that the number of fish entrained by the propeller was dependent on RPM.

Large vessels have been typically implicated because of their deep draft relative to smaller vessels, which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Larger vessels also draw more water through their propellers given their large size and, therefore, may be more likely to entrain sturgeon in the vicinity. Miranda and Killgore (2013) estimated that the high traffic of large towboats on the Mississippi River, which have an average 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 geomorphology and depth of the Mississippi River reaches and navigation channel where the study was conducted differ substantially from the action area, and as shovelnose sturgeon is a common species in the Mississippi River with densities that are likely not comparable to Atlantic sturgeon and shortnose 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 high vessel traffic can be a major source of sturgeon mortality. A similar sized tugboat moving about 11 knots was observed striking and killing an adult Atlantic sturgeon female in the Federal navigation channel in 2016 (Ian Park, DENRC, personal communication, June 2017).

As described above, recreational and smaller commercial vessels (*e.g.*, fishing boats or vessels used for shellfish husbandry) have smaller diameter propellers, entrain smaller volume of water, and have a shallow draft. Consequently, they are extremely unlikely to entrain a subadult or adult sturgeon. The most likely interaction between smaller vessels and sturgeon would be through hull or propeller strike (the moving vessel and propeller hitting the fish). In that case, the sturgeon would have to be in the water column near the surface (because of the shallow draft of smaller vessels) and unable to escape as the vessel approached. Thus, the probability of a vessel striking a sturgeon is likely related to the speed of the vessel. 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 can strike and kill Atlantic sturgeon and shortnose sturgeon when moving at high speeds and/or over shallow areas. Brown and Murphy (2010) included information on a commercial crabber reporting that his outboard engine had hit an Atlantic sturgeon in a shallow area of the Delaware River. On November 5, 2008, in the Kennebec River in Maine, the Maine Department of Marine Resources (MEDMR) staff observed a small (<20 foot) boat transiting through a known shortnose sturgeon overwintering area at high speeds. When MEDMR approached the area after the vessel had passed, they discovered a fresh dead shortnose sturgeon. They collected the fish 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 traveling 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)). However, the dense vessel activity on the Delaware River, the presence of large ships, and local and regional restrictions on speed and wake is expected to limit the high-speed activities by small vessels, especially in shallow areas. Though these observations shows that interactions with vessels are not limited to large, deep draft vessels, we believe small vessels striking sturgeon to be a very small fraction of sturgeon vessel mortalities on the Delaware River. For a shallow draft vessel to interact with a sturgeon, the sturgeon has to be near the surface at the same time as the vessel. While sturgeon do move through the water column and Atlantic sturgeon are known to jump out of the water, sturgeon are found at deeper waters the majority of time. It is therefore a low probability for a shallow draft recreational vessel to encounter a sturgeon (i.e. that a vessel at high speed is at the same location and the exact same time when the sturgeon is present near the surface). The risk of interactions will increase with a very high densities of small vessels or if a vessel transverses a location with a very high density of sturgeon. However, the combination of small propellers (i.e. small area of influence) and shallow drafts of small vessels, and the expected limited high-speed activity in areas with high vessel density makes a very low probability for a recreational vessel interacting with a sturgeon. Empirical evidence support this conclusion (Balazik *et al.* 2012b, Brown and Murphy 2010).

Other factors also affect the probability of vessel strikes. Narrow channels can concentrate both sturgeon and vessels into a smaller area and thus increase the risk of vessel strike. Balazik *et al.* (2012b) noted that there is a negative relationship between channel width and vessel mortalities in the James River. Sturgeon are likely to be higher in the water column and use navigation channels during periods of movement such as spawning migrations or seasonal movements between summer and overwintering areas (Hondorp *et al.* 2017). A higher number of adult Atlantic sturgeon vessel mortalities occur in the Delaware River during spring months. Besides being related to the immigration of adults and subadults during these months, it has also been suggested that the sturgeon behavior during migration increases their exposure to vessels (Brown and Murphy 2010, Fisher 2011).

Cargo and tanker vessels have deep drafts that reach within less than two meters of the bottom of the Navigation Channel and are equal to the depth in the berth area. The large propellers, up to ten meters in diameter, would draw water that exceeds the diameter of the propeller. As ship moves forward, the water flows around the hull, flows into the "hole" that is left as the vessel move forward, and is drawn through the propeller. Often these ships have multiple propellers. Further, while sturgeon are benthic feeders, they also use the whole water column during non-foraging movements and migrations and have even been seen jumping out of the water. Therefore, we consider all sturgeon in the path of a cargo or tanker vessel (the width of the path being equal to the width of the ship) to be located in the water column where the moving vessel will expose them to the water drawn through its propellers.

There are no studies of how sturgeon respond to approaching large vessels with deep draft. In a study of Delaware River sturgeon distribution by using a camera on a sledge, individual sturgeon did not react to the approaching sled until it was nearly upon it indicating that approaching vessels may not elicit a flight response. However, we do not know if sturgeon would be similarly docile to the sound and size of approaching large vessels. Nevertheless, a large number of carcasses found in the Delaware River as well as in James River, Virginia, indicate interactions with the propellers of large vessels (Balazik *et al.* 2012b, Brown and Murphy 2010). These observations include old juveniles and adult sturgeon of both species showing that even large sturgeon are unable to escape entrainment.

8.2.4.4 Project Vessel Interactions

As explained in the Project Description above, there would be an increase in vessel traffic in the Delaware River for the lifetime of the proposed project that would not occur but for the proposed marine terminal. Despite their relatively small number, such vessels will add to the existing vessel activity on the Federal Navigation Channel and in the Delaware River and Delaware Bay.

In this Opinion, we have considered if the increase in vessel traffic, when added to the baseline vessel traffic, would increase the risk of interactions between sturgeon and vessels in the Delaware River. There are no scientific quantitative surveys of vessel mortalities or a time series index. This complicates any evaluation of the relationship between vessel densities and sturgeon mortalities. The biological assessment assumed that the increase in vessel traffic above baseline that would result from the proposed marine terminal would increase the risk of vessel strike to shortnose and Atlantic sturgeon and that this increased risk would result in a corresponding increase in the number of sturgeon struck and killed in the Delaware River. We similarly assume that the risk of a vessel striking and killing a sturgeon is proportional to the volume of traffic in the river. Given the high baseline vessel traffic within the Federal navigation channel, an annual increase of 182 trips would correspond to an approximate 0.37% increase in vessel traffic over baseline conditions.

This section considers the effects of vessel traffic associated with marine terminal operations on sturgeon over the approximate 30-year lifetime of the project. First, we evaluate the factors determining the risk of vessel strikes by project-related vessels. We then use the calculated number of sturgeon mortalities relative to vessel activity (annual vessel trips) in the action area from our baseline section (Section 6.3.3) to calculate an estimate of sturgeon killed.

Atlantic Sturgeon

In the baseline section, it was calculated that each vessel trip killed 0.00113 Atlantic sturgeon or that one Atlantic sturgeon is killed for approximately every 883 vessel trips. As discussed in

Section 6.3.3, this is a reasonable approximation as the waterborne commerce data used included vessels of all drafts and both with and without propellers. We also consider smaller vessels to be less of a threat to sturgeon and account for only a small fraction of yearly reported sturgeon mortalities. Thus, even though the data does not account for the many recreational vessels and smaller fishing vessels that operates on the Delaware River and in the bay, we believe that the commerce data provides a close approximation of the number of vessels that are a threat to sturgeon.

The biological assessment uses the total number of vessels during 2015 as the number of vessels on the Delaware River. However, annual vessel traffic in the database has varied over the years and, as explained in Section 6.3.3, we believe that using a statistical center value as a better representation of vessel traffic on the Delaware River. Because of the skew in the data, we use the median annual number of vessel trips for the period from 2005 to 2010 of 42,398 vessel trips. In calculating annual mortalities, USACE uses average annual sturgeon mortalities for the four years from 2013 to 2016 to represent the number of yearly sturgeon vessel related mortalities occurring within the action area. We use the median during the period from 2012 to 2016 to represent vessel mortalities (median=16) within the action area. As described in Section 6.3.3, the years starting from 2012 represents the best available data as outreach efforts were increased in 2012. Both USACE and we include sturgeon with unknown cause of death as a conservative estimate of vessel mortalities. While cause of death cannot be determined with reasonable certainty for many carcasses, it is likely that most of these were vessel strikes as described in Section 6.3.3 and by Brown and Murphy (2010). At last, most sturgeon mortalities are likely never found and/or reported. We do not know the recovery ratio for the Delaware River but Balazik *et al.* (2012b) estimated that 1/3 of vessel mortalities are reported in the James River. To error on the side of the species, we multiplied the annual number of vessel mortalities by three. The USACE used the same correction factor in calculating vessel mortalities in the biological assessment. Based on the above, we calculated an estimate of 48 vessel mortalities in the Delaware River occurring annually.

USACE estimated that the operation of the proposed terminal would add 182 new vessel trips per year in the Delaware River (i.e. vessel trips that would not occur but for the proposed marine terminal) over the 30-year life span of the project. As a conservative (worst-case) assumption, we assume that all 48 Atlantic sturgeon estimated to be struck and killed annually by vessels in the Delaware River would occur in the portion of the river that would be transited by the vessels bound for the proposed facility. Thus, approximately 0.21 sturgeon would be killed by the additional vessels per year (0.00113 *182) for a total of approximately six (6) sturgeon vessel mortalities over the 30-year life span of the project. Sturgeon entrained in the propeller of vessels could also be injured but survive. This would most likely occur if interacting with a smaller propeller. The RoRo vessels have large propeller that rotates with considerable force. Therefore, we find it unlikely that a sturgeon being hit by a propeller of this size will survive and consider all sturgeon interactions with the vessels interactions analyzed in this Opinion to be fatal.

Size was reported for fewer than half of the carcasses reported since 2005. However, of the 43 Atlantic sturgeon in the DENRC data that were assumed to be struck and killed by vessels from 2012 through 2016, 13 (30.2%) were characterized as juveniles and 29 (67.4%) were characterized as adults (life stage was not determined for one or 2.3% of the fish). Murphy and Brown (2010) found that juveniles comprise 39% of Atlantic sturgeon vessel strike mortalities in the Delaware River. There are several reasons why larger sturgeon may be more frequently reported, including a reporting bias for larger carcasses, a longer persistence time in the environment, and an increased likelihood of propeller strike mortality due to body size (Killgore *et al.* 2011). However, we do not have information that makes it possible to evaluate or adjust juvenile mortality based on reporting bias or carcass persistence time. The USACE, to be conservative, in their analysis assumed all mortalities with no life stage information were adult fish. Thus, based on their dataset, juvenile and subadults deaths each account for 4.9% of vessel strike mortalities. Given that size was reported for fewer than half of the sturgeon collected, it is reasonable to assume that 4.9% underestimates the percentage of juvenile Atlantic sturgeon vessel strike mortalities. Either way, it is not possible to meaningfully predict the ratio of adult to juvenile Atlantic sturgeon estimated killed by vessels traveling to and from the proposed marine terminal. We therefore conservatively consider all of the estimated 6 vessel mortalities to be adults.

DPS

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, Atlantic sturgeon exposed to commercial vessel traffic of the proposed action originate from the five DPSs at the following frequencies: NYB 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. Based on these percentages we have estimated that vessel traffic associated with the project could struck and kill 6 Atlantic sturgeon over the 30-year life span of the project. Thus, 3.5 of the vessel mortalities would belong to the NYB, 1.08 to CB, 1.02 to SA, 0.42 to GOM, and 0.03 to Carolina. Given that we cannot have a fraction of a sturgeon killed, we round the number of sturgeon from each DPS as follows: 4 from NYB, 1 from CB, and 1 from SA or GOM. 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.

Sex ratios in spawning shovelnose sturgeon, for example, may be as high as 2.3 males to 1 female (Wheeler *et al*. 2016). Sex ratio data specific to the Delaware River population of Atlantic sturgeon are not available. A skewed sex ratio in the river during spawning might suggest that the likelihood of a vessel striking and killing a male is greater than that for a female during certain times of the year. Males usually begin their spawning migration early and leave after the spawning season, while females make rapid spawning migrations upstream and quickly depart following spawning (Bain 1997 as cited in ASSRT 2007). Assuming that the length of time that sturgeon spend within the river is correlated with an increased risk of vessel strike, this information suggests that male sturgeon are more likely than females to be struck and killed by a vessel in the action area. The DENRC data report the sex for only five adult mortalities (all causes) in the Delaware River (all years). Of these, two were determined to be female and three male. In the absence of additional information, we assume the ratio of male to female Atlantic sturgeon in the Delaware River is even (1:1) and that male sturgeon are equally as likely to be struck and killed by a vessel as female sturgeon. Therefore, out of the 4 adult vessel strikes estimated for the NYB DPS over 30 years, we anticipate approximately 2 to be male and 2 female.

Shortnose sturgeon

A total of 11 shortnose sturgeon mortalities were reported for the whole period (2005 through 2016) that DENRC has data. Of these, eight were vessel mortalities. The data contains six mortalities during the years 2012 through 2015, of which four were vessel mortalities and two with unknown cause of death. Again assuming that vessel strike caused all mortalities and that only 1/3 of all vessel mortalities are reported, 18 vessel mortalities occurred during the four years or 4.5 per year. Thus, one shortnose sturgeon is killed per 9,422 vessel trips or 0.00011 per trip. Using the same calculation as above, over the 30-year time life of the project, 0.6 shortnose sturgeon will be killed by the additional vessel activity related to the operation of the proposed terminal. Since a fraction of a sturgeon cannot be killed, we round this up to one (1) shortnose sturgeon will be killed. Given that larger fish has an exponentially higher probability of being killed if entrained through a propeller and that adults are assumed in general to be more susceptible to be exposed to vessels (Miranda and Killgore 2013, USACE 2017a), we consider it significantly more likely that the vessel mortality will be an adult than a juvenile.

8.2.4.5 Summary of Effects of Vessel Traffic

We expect the additional vessel traffic in the action area due to the operation of the marine terminal increases the risk of vessel strike in the action area. Based on this, we have concluded that the increase in traffic in the vessel impact area is likely to result in an increase in the number of sturgeon killed by vessels in this area. We assume that vessels docking at the marine terminal will stay constant and that the risk will not increase during the next 30 years of terminal operation. It is difficult to quantify any change in the risk of strike in the Delaware River Federal Navigation Channel for all cargo types given the uncertainty in where the vessels will travel and the extent the proposed terminal will result in redistribution of vessel traffic among existing terminals rather than an increase. Based on information in the biological assessment, the development of the new terminal will only result in an increase of 91 new vessels transporting Roll-on/Roll-off cargo. We have therefore only considered these vessels when calculating risk of sturgeon being struck by a vessel. Based on this, we anticipate that no more than six (6) adult sturgeon will be killed during the 30 years of terminal operation. Four (4) 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 (1) adult shortnose sturgeon will be killed by RoRo vessels transiting the Delaware River during 30 years of terminal operation.

We have made a number of assumptions (as identified above) in our analysis in light of the uncertainty surrounding a number of issues. These include:

- The contribution of recreational vessels to total vessel traffic in the action area was not considered which would overestimate the risk of vessel mortalities per trip if recreational vessels are a larger threat than assumed;
- the baseline vessel traffic included commercial vessels of all drafts and vessel without propeller whish likely underestimate the risk of sturgeon being killed by project related cargo and tanker vessels;
- the assumption that all vessels are equally likely to strike a sturgeon and that the consequences of that strike would be the same (which could result in an underestimate or overestimate)

- the inclusion of sturgeon recorded in the DENRC database that had no identified cause of death in the number of vessel mortalities which would overestimate the risk of vessel strike if many of these were actually not killed by interaction with vessels;
- the assumption that the DENRC database includes only1/3 of sturgeon mortalities (which would result in overestimate if a higher portion is reported and an underestimate if even less are reported); and
- the use of annual vessel activity and sturgeon mortalities as most mortalities are reported during spring which could either over or under estimate (depending on baseline vessel activity during different months) the risk of vessels striking a sturgeon.

We have used the best available information and made reasonable conservative assumptions in favor of the species to address uncertainty and produce an analysis that results in an estimate of the number of interactions between sturgeon and vessels that are reasonably certain to occur.

8.2.5 *Water Quality Effects from Adjacent Upland Activities*

This section discusses water quality effects from adjacent upland construction and operations activities. Water quality in riverine and estuarine systems is affected by human activities conducted in the riparian zone, as well as those conducted more remotely in the upland portion of the watershed. This development contributes to temperature variations, and releases of metals, dioxins, dissolved solids, phenols and hydrocarbons, any of which may be acutely or chronically toxic to fish, depending on dose. A total of 13 Superfund sites are located in Marcus Hook; an additional waste site has not been designated as a Superfund site (NMFS 2015).

Adjacent upland activities for the proposed marine terminal include development a marine terminal with facilities for automobile import/export and processing, handling of general freight, break bulk cargo, and bulk liquid storage. Although the USACE do not regulate this work, construction and operations of the marine terminal on the adjacent upland area have the potential to negatively affect water quality and therefore impact sturgeon species in the river. Several activities or incidents, including those caused by human error, may contribute to a degradation of water quality. Upland eroded soil, spills of petroleum products, leakage of hydraulic fluids from equipment, catastrophic spills during storage in facilities and during cargo-off and on- loading, and chemicals in stormwater can enter waters of the Delaware River. Further, disconnection of floodplain and tidal wetlands from river channel and loss of riparian vegetation that supports terrestrial insects with aquatic life stages will reduce forage for early life stages.

Although early life stages of sturgeon as well as juvenile, subadult (Atlantic) and adult sturgeon are expected to be present adjacent to the project site during upland construction and operation of the proposed marine terminal, there are no pathways of effects from upland activities to the water and thus early as well as adult life stages of sturgeon will not be exposed to any stressors from upland activities.

Activities that have the potentially to adversely affect water quality are regulated by the NJDEP, USCG and the EPA as well as the Gloucester County Soil Conservation District. During storm events that generate overland water flow, urban runoff and runoff from upland construction activities may transport chemicals and TSS through the storm sewer system to the Delaware River. Storm events are intermittent and last for a relatively short duration. In addition, any increase in solids would likely be minimal due to the large volume of runoff generated in storm events. As described Section 2.8, the project would implement several management plans and permitting requirements to prevent upland construction activities from significantly degrading water quality of the river. Measures to protect water quality during construction include obtaining a general construction stormwater permit for construction of upland facilities and implementing of a SESC plan approved by Gloucester County to control soil erosion sedimentation of waterways. Typical SESC plan requirements include installation sediment barriers, runoff basins, inlet protection, and permanent stabilization (*e.g.* planted slopes, retaining walls, or rip-rap). Together, these controls mitigate the pathway for sediment-laden runoff to reach the Delaware River. As required by the general construction stormwater permit, an SPPP also will be developed. The SPPP plan requires routine and post-storm event inspections of applicable SESC requirements and stormwater best management practices to ensure the effectiveness of the SPPP. A State Section 401 Water Quality Certification was issued on April 10, 2017 in conjunction with a Waterfront Development permit for the marine terminal. State water quality regulations are designed to protect against degradation of water quality as a result of construction. Therefore, as the pathway for water quality effects on the Delaware River has been sufficiently controlled by implementation of state and Federal regulations, we anticipate that any effects from upland construction will not change the baseline in any way that can be meaningfully measured, detected, or evaluated. Effects of upland construction on water quality are therefore insignificant.

The Applicant indicates that it will also obtain permits and implement management plans to protect water quality during operation of the proposed marine terminal. As detailed in Section 3.8.4, the facility must meet applicable requirements of programs that are intended to control, contain and mitigate release of chemicals into the environment. Six outfall structures will be installed along the shoreline of the site to support stormwater management from the marine terminal. If polluted or turbid waters were discharged from these outfalls, upland operations may contribute to a degradation of water quality within the Delaware River. Project outfalls were designed to meet water quality requirements specified in New Jersey's Stormwater Management Rules (N.J.A.C. 7:8). In addition, a New Jersey Pollutant Discharge Elimination System industrial stormwater general permit will be obtained prior to construction and use of the outfalls. The general permit requires industrial exposure to stormwater be eliminated, or an individual NJPDES permit is required.

Delaware River Basin Commission (DRBC) stream quality objectives for this section of the Delaware River (Zone 4) would serve as the basis for establishing individual NJPDES permit limitations. These objectives are protective of the current water uses for Zone 4 of the Delaware River, including maintenance of resident fish and other aquatic life, passage of anadromous fish, and wildlife. Typical parameters monitored include oil and grease, TSS, biological oxygen demand (BOD), temperature, and pH. Where applicable, additional site-specific monitoring parameters may be added to the permit to monitor effluent discharging into the river.

Stormwater treatment for the proposed upland development was designed to meet 50% TSS removal for all redeveloped impervious coverage and 80% TSS removal for all new impervious cover and new gravel associated with vehicular traffic, as required by NJDEP (Langan 2016). Because most particulate matter will be removed from the stormwater before entering the waters of the Delaware River, the water discharged to the Delaware River from the outfalls of the proposed marine terminal will not be significantly more turbid than background levels in the Delaware River. In addition, the volume of water discharged to the river would be extremely small relative to the volume of water in the river such that any suspended particles will be highly diluted. Therefore, any suspended particulate matter in the water coming out of the outfalls when added to suspended sediment of the waters of the river may result in only a minor increase in turbidity along the shallow shoreline directly where the outfalls empties into the Delaware River if any increase can be detected at all. As no manufacturing is planned for the site at the present time, the project does not propose to discharge any industrial effluents or wastewater. Consequently, stormwater discharges would not contribute chemicals to the action area. Sewage would be treated through the local publically owned treatment works and would not be discharged to onsite waters. During operation of the marine terminal, additional measures to minimize impacts to water quality, such as the development of spill prevention and control measures, would be implemented as required by regulation (refer to Section 3.8). Therefore, we do not anticipate any measureable effects on water quality from stormwater management, and effects on sturgeon are insignificant.

Compliance with state and Federal permitting requirements will ensure that landside activities do not adversely affect water quality in the Delaware River. Specific requirements include:

- Monitoring for compliance with all applicable effluent limits on stormwater, such as TSS, BOD, oil and grease, and pH;
- Design of facility drainage to prevent uncontrolled discharges, including installation of security measures (*e.g.* emergency cutoff valves) and secondary containment;
- Development of emergency planning and response actions for handling spills; and
- Regular monitoring and inspection of stormwater management facilities and potential sources of pollution (*e.g.* storage containers).

In addition to stormwater management, the facility also would be required to comply with Federal and state regulations that are intended to control, contain and mitigate release of chemicals to the environment. The Applicant will implement a SPCC and FRP as required. These Federal plans are designed to prevent uncontrolled releases of chemicals and to ensure that facilities have an adequate response in the event of a worst-case discharge. Through implementation of these plans, the pathway for chemicals to enter the river would be minimized the maximum possible extent.

The implementation of practices required by Federal and state agencies listed above would prevent and/or mitigate releases from the marine terminal to adjacent waterways. Therefore, we do not anticipate measurable effects to water quality from the construction or operation of the upland terminal facility, and effects of water quality on sturgeon are insignificant.

Construction of upland marine terminal facilities will result in the loss of approximately 3 acres of vegetation within the 50 ft. riparian zone[23] of the Delaware River. This area has already been disturbed by historical industrial activity and has been disconnected from the river by a rip rapped levee. The limited vegetation present in the riparian zone generally consists of invasive species, including common reed (*Phragmites australis*) and mile-a-minute weed (*Persicaria*

23 Riparian zone width as determined by New Jersey Flood Hazard Area Protection Act Regulations (N.J.A.C. 7:13)

perfoliata). Given that the riparian zone is dominated by a rip rapped shoreline that will not be significantly altered by the project, a small loss of riparian zone vegetation currently dominated by invasive species would have an insignificant effect on sturgeon. In addition, a combined 4.789 acres of wetlands and State open waters would be impacted by construction on the landward side of the marine terminal. None of these wetlands are directly connected to the Delaware River; therefore, impacts to these wetlands would not affect sturgeon.

Riverfront development has the potential to alter the connectivity between the river and adjacent floodplain and disrupt natural processes, such as sediment and nutrient transfer (Noe and Hupp 2005). Due to historical development and industrial use, much of the lower Delaware River is disconnected from the floodplain by berms and raised shorelines. Construction of the upland marine terminal would occur within the floodplain and a NJDEP Flood Hazard Area Individual Permit was issued by NJDEP on April 10, 2017 in conjunction with the Waterfront Development Permit. The project site is a previously developed brownfields site that has already been physically separated from the Delaware River through a series of tide gates, levees, and berms. The project would partially reconnect the marine terminal watershed to the river by allowing surface water to flow to the river via an NJDEP-permitted outfall instead of being retained behind a series of levees and floodgates. The proposed development may increase floodplain connectivity to the river but the relative effect would be insignificant. Therefore, no effects to listed species are expected to result from upland construction activities within the floodplain.

In summary, through the implementation of plans and practices required by Federal and state agencies, no measureable effects on water quality from stormwater management or marine terminal operations are expected. Upland construction activities within the floodplain, including the small loss of riparian zone vegetation dominated by invasive species, would have an insignificant impact on listed species.

8.2.6 *Effects of Mitigation Activities*

Mitigation would be performed for unavoidable losses to SAV and intertidal/subtidal shallows within the construction area. Mitigation for impacts to 0.064 acres of SAV is currently under review by NJDEP, but would involve creation/enhancement of SAV within the Delaware River at or near the project site. Measures would be taken to minimize impacts to listed species during SAV mitigation. Divers that harvest and plant aquatic vegetation within waters of the Delaware River may disturb any sturgeon in the vicinity, elicit startle behaviors, and result in the sturgeon leaving the immediate area where the mitigation activities take place. Thus, sturgeon may suspend activities such as foraging, resting, or up- and downstream movement. These disturbances will be temporary, and we expect the sturgeon to move to nearby areas or habitat patches where it will take up any activities it was engage in when disturbed. Thus, suspension of activities will be of such short duration and movements of short distances that effect, if any, on the fish would be so small that they cannot be meaningfully measured, detected, or evaluated; effects are insignificant. Further, this mitigation would provide foraging habitat and improve water quality, potentially benefitting listed species in the action area.

Mitigation for impacts to intertidal/subtidal shallows and coastal wetlands would be conducted through the purchase of credits from the Abbott Creek Wetland Mitigation Bank located in Fairfield Township, Cumberland County, New Jersey. The bank give credit primarily for tidal marsh and mudflat restoration/enhancement as well as freshwater emergent and scrub-shrub wetland enhancement and an upland enhancement area that will be managed as quail habitat.

Since the habitat that this bank manage does not include open water habitat, the mitigation for impacts to intertidal/subtidal shallows and coastal wetlands at the project site will not affect sturgeon.

9 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[24].

State Water Fisheries - Future recreational and commercial fishing activities in state waters may take shortnose and Atlantic sturgeon. In the past, it was estimated that over 100 shortnose sturgeon were captured annually in shad fisheries in the Delaware River, with an unknown mortality rate (O'Herron and Able 1985); no recent estimates of captures or mortality are available. Atlantic sturgeon were also likely incidentally captured in shad fisheries in the river; however, estimates of the number of captures or the mortality rate are not available. Recreational shad fishing is currently allowed within the Delaware River with hook and line only; commercial fishing for shad occurs with gill nets, but only in Delaware Bay. In 2012, only one commercial fishing license was granted for shad in New Jersey. Shortnose and Atlantic sturgeon continue to be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to shortnose and Atlantic sturgeon are likely less than they were in the past.

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

State PDES Permits – The states of New Jersey, Delaware and Pennsylvania have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Permitees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through

[24] 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."

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.

Port of Philadelphia

The State of Pennsylvania has announced a 300 million dollar Capital Investment Program for the Port of Philadelphia infrastructure, warehousing, and equipment (Office of Pennsylvania Govenor Tom Wolf 2017). The investment will fix ship berths, buying new cranes, updating and relocating warehouses, and doubling the cargo-handling space of the Port of Philadelphia, including the Packer Avenue Marine Terminal, the Port's automobile-handling operation, and the Tioga Marine Terminal.

The Governor's office reports that improvements will result in a doubling of container capacity at the Port, provide increased breakbulk (non-containerized) cargo capacity, and bring a substantial increase in automobile-handling capacity (Office of Pennsylvania Govenor Tom Wolf 2017). The investment will start in 2017 and continue to 2020. The State will invest about $188 million of the Capital Investment Program in the Packer Avenue Marine Terminal, the Port of Philadelphia's largest maritime facility (Loyd 2017). These improvements will include investment in four new electric new-Panamax container cranes, the relocation of old and the construction of new warehouses to facilitate container growth, and a deepening to 45-foot depth of the terminal's marginal berths to match the new 45-foot depth of the Delaware River's main channel. Electrification throughout the terminal will also be modernized to support electrification of existing diesel cranes and cold ironing capabilities at the terminal (the ability to power without the need for the vessels to burn fuel while docked). The deepening of the berth and any in-water work will require a DOD permit and is not part of cumulative effects. However, increase vessel traffic as well as changes in the vessel type (i.e., larger with deeper draft) seeking port as a consequence of landward improvements to increase vessel capacity are not under federal jurisdiction.

Deepening of the berth, installation of "post-Panmax" container cranes, infrastructure improvements, and rebuilding of warehouses at the Packer Avenue Marine Terminal will double cargo handling from 456,000 to 900,000 containers annually and may reach 1.2 million in the future (Loyd 2017, Office of Pennsylvania Govenor Tom Wolf 2017). The Philadelphia Auto Port (Southport site) parking lot will be increased with 155 acres resulting in an increase in annual imports from 155,000 to 350,000 (Loyd 2017). At last, improvements to the main on-dock warehouse and other infrastructure investments at the Tioga Marine Terminal are projected to increase break bulk cargo with 21 percent (Loyd 2017, Office of Pennsylvania Governor Tom Wolf 2017).

While these investments will increase cargo handling at the Port of Philadelphia, it is not possible to quantify how this will increase number of vessels seeking port at the terminal facilities and, consequently, the risk of a sturgeon being struck by a vessel. This because the deepening of the Federal Navigation Channel and the port combined with expansion of the Panama Canal will result in larger vessels with larger cargo capacity. Thus, the increase in the terminals cargo handling capacity may be partially met by larger vessels with larger cargo capacity rather than by an increase in number of vessels. However, the port facilities will service new vessels through a vessel –sharing alliance of multiple companies that deploys 240 vessels (Loyd 2017).

For some terminals, the deepening of the navigation channel to 45 feet may reduce the risk of entrainment in vessel propellers as the berth can only handle vessels with shallower draft. Thus, the draft of vessels relative to channel depth will decrease such that sturgeon have more space to avoid propellers. This will not be the case for the State investment in the Port of Philadelphia. The port's ability to handle larger ships with deeper draft will continue to pose significant threats to sturgeon as draft of these new vessels will continue to be close to the riverbed. Further, we expect the larger ships to have larger propellers with a larger thrust and larger area of influence, thereby increasing risks of sturgeon vessel mortality or injury from an individual vessel. Vessels with deep draft also affect bottom habitat through propeller scour or direct contact that result in resuspension of sediment and increase turbidity (Hong et al. 2013, Hong et al. 2016, Karaki and van Hoften 1975). It is possible that such turbulence also can dislodge sturgeon eggs and free embryos (yolk sac larvae) from the riverbed.

10 INTEGRATION AND SYNTHESIS OF EFFECTS

In the effects analysis outlined above, we considered potential effects from the following sources: (1) deepening of the access channel and berth with cutterhead and mechanical dredges; (2) pile driving for construction of the wharf platforms; (3) physical alteration of the action area including effects to benthic communities, substrate type, and salinity, and (4) project vessel activity within the action area during construction. In addition to these categories of effects, we considered the interrelated and interdependent activities. These include upland activities during construction and operation of the proposed marine terminal, catastrophic spills during operation of the proposed marine terminal, and the potential for operation of the terminal to result in an increase in vessel traffic in the action area and the potential for vessel-sturgeon interaction. We anticipate the mortality and injury of a small number of shortnose sturgeon and Atlantic sturgeon from the five DPSs. Mortality of Atlantic and shortnose sturgeon will occur from interaction with vessels during operation of the proposed marine terminal. As explained in the "Effects of the Action" section, effects of all activities considered except vessel traffic during operation of the proposed marine terminal will be insignificant and discountable, including vessel traffic, dredging, and pile driving during construction.

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

10.1 Shortnose sturgeon

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

The Delaware River population of shortnose sturgeon is the second largest in the United States. Historical estimates of the size of the population are not available as historic records of sturgeon in the river did not discriminate between Atlantic and shortnose sturgeon. The most recent population estimate for the Delaware River is 12, 047 (95% CI= 10,757-13,580) and is based on mark recapture data collected from January 1999 through March 2003 (ERC Inc. 2006). Comparisons between the population estimate by ERC Inc. and the earlier estimate by Hastings *et al.* (1987) of 12,796 (95% CI=10,228-16,367) suggests that the population is stable, but not increasing.

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

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Delaware River are affected by impingement at water intakes, habitat alteration, dredging, bycatch in commercial and recreational fisheries, water quality and in-water construction activities. It is difficult to quantify the number of shortnose sturgeon that may be killed in the Delaware River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions we obtain some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Delaware River each year, with little if any mortality. With the exception of the five shortnose sturgeon observed during dredging activities in the 1990s, and the shortnose sturgeon killed during the pilot relocation study, we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. We also have no quantifiable information on the effects of habitat alteration or water quality; in general, water quality has improved in the Delaware River since the 1970s when the CWA was implemented, with significant improvements below Philadelphia which was previously considered unsuitable for shortnose sturgeon and is now well used. Shortnose sturgeon in the Delaware River have full, unimpeded access to their historic range in the river and appear to be fully utilizing all suitable habitat; this suggests that the movement and distribution of shortnose sturgeon in the river is not limited by habitat or water quality impairments. Impingement at the Salem nuclear power plant occurs occasionally, with typically less than one mortality per year. In high water years, there is some impingement and entrainment of larvae at facilities with intakes in the upper river; however, documented instances are rare and have involved only small numbers of larvae. Bycatch in the shad fishery, primarily hook and line recreational fishing, historically may have impacted shortnose sturgeon, particularly because it commonly occurred on the spawning grounds. However, little to no mortality was thought to occur and due to decreases in shad fishing, impacts are thought to be less now than they were in the past. Despite these ongoing threats, the Delaware River population of shortnose sturgeon is stable at high numbers. Over the life of the action, shortnose sturgeon in the Delaware River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Delaware River population. If the salt line shifts further upstream as is predicted in climate change modeling, the range of juvenile shortnose sturgeon is likely to be restricted. However, because there is no barrier to upstream movement it is not clear if this will impact the stability of the Delaware River population of shortnose sturgeon; we do not anticipate changes in distribution or abundance of shortnose sturgeon in the river due to climate change in the time period considered in this Opinion. As such, we expect that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

We have estimated that the ongoing operation of the marine terminal will result in the mortality of one shortnose sturgeon by vessel strike over the next 30 years. We expect that the shortnose sturgeon killed could be a juvenile or an adult though it is more likely that it will be an adult. All other effects to shortnose sturgeon, including effects to habitat and prey due to dredging and dredge disposal, will be insignificant and discountable.

The one shortnose sturgeon that is likely to die as a result of the ongoing use through 2047 of the marine terminal, represents an extremely small percentage of the shortnose sturgeon population in the Delaware River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon rangewide, which is also stable. The best available population estimates indicate that there are approximately 12,047 shortnose sturgeon in the Delaware River (ERC 2006). The death of one adult shortnose sturgeon will not change the status of this population or its stable trend as this loss represents an undetectable change in the reproductive potential of the Delaware population. 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 one shortnose sturgeon over a 30-year period would affect the success of spawning in any year. Additionally, this small reduction in potential spawners is not expected to result in a small reduction in the number of eggs laid or larvae produced in future years and similarly, a no 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 very small and would not change the stable trend of this population. Additionally, the proposed action will not affect spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds.

The proposed action is not likely to reduce distribution of Delaware River because while the action will affect the distribution of individual sturgeon locally during pile driving and dredging, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. Further, the action is not expected to reduce the river by river distribution of shortnose sturgeon. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed action is an extremely small fraction, less than 1%, of the Delaware River population, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity.

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

Based on the information provided above, the death of up to one shortnose sturgeon over a 30-year period resulting from the ongoing operation of the marine terminal through 2047, will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect shortnose sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter (i.e., it will not increase the risk of extinction faced by this species). This is the case because: given that: (1) the population trend of shortnose sturgeon in the Delaware River is stable; (2) the death of up to one 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 the 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 the shortnose sturgeon will not change the status or trends of the Delaware River population or the species as a whole; (4) the action will have only a minor and temporary effect on the distribution of shortnose sturgeon in the action area (related to movements around the working dredge and during pile driving) and no effect on the distribution of the species throughout its range; and, (5) the action will have no effect on the ability of shortnose sturgeon to shelter and only an insignificant effect on individual foraging shortnose sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing under ESA Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer warranted. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that shortnose sturgeon can rebuild to a point where shortnose sturgeon are no longer in danger of extinction through all or a significant part of their range.

A Recovery Plan for shortnose sturgeon was published in 1998 pursuant to Section 4(f) of the ESA. The Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely. However, the plan states that the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks, (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, migrating, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the Delaware River population of shortnose sturgeon in a way that would affect the species' likelihood of recovery.

The Delaware River population of shortnose sturgeon is stable at high numbers. This action will not change the status or trend of the Delaware River population of shortnose sturgeon or the species as a whole. This is because the reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged or blasted and most foraging occurs outside of the areas where deepening and maintenance dredging and blasting will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and anticipate any changes to the salinity regime to be minor. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area.

The proposed action will not affect shortnose sturgeon outside of the Delaware River. Because it will not reduce the likelihood that the Delaware River population can recover, it will not reduce the likelihood that the species as a whole can recover. Therefore, the proposed action will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

10.2 Atlantic sturgeon

We have determined that the development of the proposed marine terminal will result in vessel strike and mortality of six (6) subadult or adult Atlantic sturgeon within the action area over a 30-year period. We cannot predetermine with certainty what DPS any of these takes will belong to but based on existing mixed stock genetic analyses of near shore and riverine fish, we have determined that four (4) of the vessel mortalities would be of NYB origin, one (1) of CB origin, one (1) of CB or GOM, and none from of Carolina origin.

10.2.1 *Gulf of Maine DPS*

While GOM DPS Atlantic sturgeon occur in several rivers in the Gulf of Maine, recent spawning has only been documented in the Kennebec and Androscoggin rivers. No total population estimates are available for any river population or the DPS as a whole. As discussed in section 4.7, we have estimated a total of 7,544 GOM DPS adults and subadults in the ocean (1,864 adults and 5,591 subadults). This estimate is the best available at this time and represents only a percentage of the total GOM DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. GOM origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. While there are some indications that the status of the GOM DPS may be improving, there is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

Based on mixed-stock analysis, we expect that 7% of the subadult and adult Atlantic sturgeon in the action area will originate from the GOM DPS. Thus, we expect that no more than one GOM DPS Atlantic sturgeon will be killed vessel traffic related to the proposed development of the marine terminal. This mortality will occur between the completion of the terminal and the end of 2047. Though GOM DPS adults could be present in the Delaware River, we do consider that it is most likely that the vessel mortality will be a subadult.

The one subadult GOM DPS Atlantic sturgeon we expect to be killed due to the ongoing project (one between now and the end of 2047) represents an extremely small percentage of the GOM DPS. While the death of one subadult or adult 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 number will change the status of this species as this loss represents a very small percentage of the GOM DPS population of subadults and an even smaller percentage of the overall DPS as a whole. Even if there were only 5,591 subadults in the GOM DPS, this loss would represent only 0.0002% 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 one female subadult would have the effect of reducing the amount of potential reproduction as any dead GOM DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the total 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 one male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning. The proposed action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn.

The proposed action is not likely to reduce distribution because while sturgeon may temporarily avoid areas where dredging or disposal activities are underway, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. We do not anticipate that any impacts to habitat will impact how GOM DPS sturgeon use the action area.

Based on the information provided above, the death of no more than one subadult GOM DPS Atlantic sturgeon over 30 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 one GOM DPS Atlantic sturgeon represents an extremely small percentage of the population of the DPS; (2) the death of one GOM DPS Atlantic sturgeon will not change the status or trends of the DPS as a whole; (3) the loss of one GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of one subadult GOM DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the DPS; (5) the action will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the DPS throughout its range; and, (6) the action will have only an insignificant effect on individual foraging, migrating, or sheltering GOM DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer warranted. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can rebuild to a point where it is no longer in danger of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

A Recovery Plan for the GOM DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for GOM Atlantic sturgeon, individuals must have access to enough habitat in suitable condition for foraging, migrating, resting, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the GOM DPS likelihood of recovery.

This action will not change the status or trend of the GOM DPS as a whole. The proposed action will result in a small amount of mortality (one subadult from a population estimated to have at least 5,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the stable trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to loss of prey in areas being dredged and most foraging occurs outside of the areas where dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type or to the salinity regime. 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.

10.2.2 *New York Bight DPS*

We have estimated that four subadult or adult Atlantic sturgeon of NYB DPS origin will be killed over a 30-year period by vessel traffic related to the proposed marine terminal. We have limited information from which to determine the percentage of NYB DPS fish in the Delaware River that are likely to originate from the Delaware River vs. the Hudson River. Of the 11 fish captured in the Delaware River for which genetic assignments are available, six were from the New York Bight DPS, with four originating from the Delaware River and two from the Hudson River. This suggest that within the Delaware River, the composition of New York Bight fish is approximately 2/3 originates from the Delaware River and 1/3 from the Hudson River. If we assume that Atlantic sturgeon killed are adults and most are killed during spawning migrations, then the vessel mortalities are more likely to be Delaware River than Hudson River origin fish even though some exchange of spawners may occur between rivers.

Males may be more likely to be interact with vessels than females based on behavioral differences between males and females during spawning. However, we do not have any data to determine sex of vessel mortalities and the few carcasses where sex was indicated were of about equal number female and male. For the purpose of this jeopardy analysis, we assume that the operation of the proposed marine terminal will result in an equal number males and females killed or injured.

We also considered the effect of construction activities and other activities related to operation of the proposed marine terminal on Atlantic sturgeon. We found that vessel activities during construction of the proposed marine terminal will not increase the risk of vessel strike. Pile driving may result in noise levels that would injure Atlantic sturgeon and shortnose sturgeon. However, we found it reasonably certain that sturgeon would react to pile driving by moving away from the piles or avoiding the ensonfied area. Thus, sturgeon is extremely unlikely to be exposed to noise levels that will cause injury or mortality. The movements and avoidance behaviors will not result in changes to essential behaviors such as feeding, resting, or breeding that will cause effects to sturgeon that are large enough to be meaningfully measured, detected, or evaluated. Construction activities or operation of the proposed marine terminal will result in local redistribution of Atlantic sturgeon but not restrict movements up or down river or access to foraging, resting, overwintering, or spawning habitat. The reconstruction and dredging of the berth will result in the degradation of 27 acres of Atlantic sturgeon foraging habitat within the Delaware River. However, we determined that this loss would not adversely limit forage available to Atlantic sturgeon of any life stage or result in reduced growth or fecundity. We also evaluated impacts to water quality from on upland construction activities, stormwater management, and from the daily operation of the proposed marine terminal such as spills and leaks. Our analysis determined that the development and operation of the proposed marine terminal will not result in an increased level of TSS or contaminants that would adversely affect any life stage of Atlantic sturgeon. Activities related to establishing SAV to mitigate for loss of existing SAV within the proposed berth area may cause behavioral disturbance but will not result in adverse effects.

Small populations are susceptible to threats such as genetic drift (allele frequencies of a population change over generations due to chance), demographic stochasticity (chance independent events of individual mortality and reproduction, causing random fluctuations in population growth rate), Allee effect (mean individual fitness in a population decreases with decreasing population size), and catastrophic events. These factors have substantial influence on the growth of small populations and therefore their extinction risk. The specific biology and life history of a species influence the population size needed to remain viable but as a rule of thumb an effective population size, N_e, of 50 breeding individuals are needed for a short-term minimum viable population (MVP) and a N_e size of 500 breeding individuals for long-term MVP (Jamieson and Allendorf 2012). The short-term viability only takes into account inbreeding while the latter only considers genetic drift[25]. In theory, a census population of 5,000 is needed for a N_e of 500 (Jamieson and Allendorf 2012). This "rule of thumb" does not considering other factors such as environmental variability, catastrophic events, or meta-population dynamics.

Only the Delaware River and Hudson River within the NYB DPS currently supports spawning, at least in any significant extent. As noted in the status of the species section, the Delaware River together with the Hudson River historically supported some of the largest Atlantic sturgeon populations. The Delaware River may have supported a population of 100,000 prior to overfishing for the caviar marked resulted in substantial declines. Though we do not have data to estimate the current Atlantic sturgeon river population in the Delaware River, the ASSRT concluded that the existing number of adult Atlantic sturgeon originating from the Delaware River is likely to consist of 300 or less individuals. An estimated 3,656 age-1 individuals used the Delaware Estuary as a nursery in 2014 (since oceanward migration begins at age two or older, these juveniles would be of Delaware River origin). As with the Delaware River Atlantic sturgeon, the Hudson River population was historically large, possibly 10,000 adult females. Current population is estimated at an annual average of 863 mature adults of which 267 are females. While the size of the Delaware River and Hudson River populations cannot be determined with reasonable certainty, all available information indicates that the populations are well below the long-term MVP.

We estimated that operation of the proposed marine terminal will add 4 vessel mortalities of subadult and/or adult sturgeon from the NYB DPS over the next 30 years. While we cannot pre-determine the origin of these fish, it is likely that some of these will be of Hudson River origin. Similarly, we cannot predetermine the sex of these fish but assuming a 1 to 1 sex ratio, it is likely that two of these will be females. While the proposed marine terminal is likely to remove adult fish from the population, it is unlikely that the four mortalities will reduce the population to a level where survival and recovery will be further hampered. The mortalities will occur over a 30-year period and will not substantially affect the effective population size. Further, while the Delaware and Hudson populations are genetically distinct they are not genetically isolated. Even a small number of immigrants per generation will reduce the risk of genetic drift (Mills and Allendorf 1996).

A population with a negative population growth will eventually go extinct. However, a species remains prone to extinction as long as they remain small and, thus, the rate of population growth, even if positive, will influence survival and recovery. Further, variation in abundance affect extinction risk. Higher variation increase the probability of bottlenecks decreasing genetic

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25 The N_e needed to balance between loss of additive genetic variation through genetic drift and creation of new genetic variation through mutation for a population to retain sufficient quantitative genetic variation to allow future adaptive change or evolutionary potential.

variation and population fitness, probability of the population being reduced below the ability for positive population growth, and the risk or real or virtual extinction. Mortality, fecundity, and generation time determines population growth. Variation of any of these three factors will result in variation in abundances over time.

ASMFC (2007) found that a 5% bycatch mortality of adults was not sustainable. The percentage is less if considering subadults as loss of these have a greater impact on population growth. Brown and Murphy (2010) similarly concluded that the loss of 2.5% of females per year from vessel strike would hamper recovery of the Delaware River Atlantic sturgeon population. It is difficult to quantify the number of Atlantic sturgeon killed in the Delaware River each year by anthropogenic sources. Approximately 5 Atlantic sturgeon mortalities have occurred since 2010 as part of the deepening and maintenance of the Delaware River Federal Navigation Channel. The Salem and Hope Creek Nuclear Generating Stations had 11 dead Atlantic sturgeon on trash racks during 2012 and 2013. Over the period from 2005 to 2016, the DENRC sturgeon mortality data (all causes) include from 6 to 23 dead Atlantic sturgeon per year. Bycatch in fisheries has killed an estimated 352 to 1,286 subadults and adults during the 2006 to 2010 period, and gillnet and otter trawl fisheries killed an estimated 391 Atlantic sturgeon during 2006 and 2010 period. The 2013 stock assessment estimated that 91 percent of the Atlantic sturgeon ocean population was of Hudson River origin. The Delaware River is the only other river of NYB DPS Atlantic sturgeon that produces any substantial number of Atlantic sturgeon. Thus, of the subadult and adult fisheries mortalities during the period from 2006 to 2010, we estimate that between 32 and 116 Delaware River origin Atlantic sturgeon were killed as bycatch. Though we do not have accurate mortality rates or know with certainty the population of adult Atlantic sturgeon in the Delaware River, we do conclude that observed mortality probably exceed sustainability and impact survival and recovery of the Delaware River population. If the adult population consist of 150 females, then the loss of more than 4 adult female sturgeon mortalities per year from vessel strike would hamper recovery (Brown and Murphy 2010). We know that over the period from 2005 to 2016, at least 65 subadult and adult likely vessel mortalities occurred and maybe as many as 195 if taking into account that most carcasses are unlikely to be found or reported. Of the reported 65 vessel mortalities, 26 likely were of Delaware River origin (adjusting for mixed stock composition [58% NYB DPS] and ratio [2/3] of Delaware to Hudson origin). Thus, the number of vessel strike mortalities is likely close to exceeding the sustainable level if the female adult population consists of 150 individuals.

Vessel-sturgeon interactions is expected to increase from a median of 48 to 62 Atlantic sturgeon per year (assuming only 1/3 of all mortalities are discovered) over the next 30 years based on projected increase in vessel traffic on the Delaware River. Based on mixed stock analysis, we expect about 58 percent to be NYB DPS. In addition, a loss of 48 NYB DPS Atlantic sturgeon of which up to three adults are anticipated by the Delaware River deepening over a 51 year period (average of less than one per year) and 85 juvenile and 6 adult NYB DPS Atlantic sturgeon over 50 years (since 2014) at the Salem and Hope Creek Generating Stations.

The operation of the proposed marine terminal will add four Atlantic sturgeon NYB DPS subadult or adult vessel mortalities during a 30-year period or an average of 0.13 mortalities per year. Even if all mortalities were females, this small reduction in potential future spawners is expected to result in an small reduction in the total number of eggs laid or larvae produced during the 80-year life span of the project and similarly, an extremely small effect on population growth or 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. Sturgeon are long-lived species and population variability is expressed over decades. Thus, adding the loss of four adult sturgeon to existing baseline mortality will not appreciably affect population viability over the next 30 years.

While the NYB DPS has experienced significant population decline, it is estimated to consist of a larger number of individuals than any of the other four Atlantic sturgeon DPSs. As discussed in section 5.1.2, 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. However, since the proposed marine terminal is unlikely to affect the viability of the Delaware River population, the estimated loss adults and larvae from the population is unlikely to reduce the likelihood for survival of the DPS as a whole.

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 can rebuild to a point where it is no longer in danger of extinction through all or a significant part of its range.

A Recovery Plan for the NYB DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting, migrating, and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the NYB DPS likelihood of recovery.

This action will not change the status or trend of the Hudson or Delaware River populations of Atlantic sturgeon or the status and trend of the NYB DPS as a whole. The proposed action will result in a small amount of mortality (no more than 4 individuals over a 30 year period) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged and most foraging occurs outside of the areas where dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type or to the salinity regime. 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.

10.2.3 *Chesapeake Bay DPS*

Subadults and adults originating from the CB DPS occur in the action area. The CB DPS is listed as endangered. Based on Mixed Stock Analysis, about 18 percent of the subadult and adult Atlantic sturgeon in the action area likely originate from the CB DPS. While Atlantic sturgeon occur in several rivers in the CB DPS, recent spawning has only been documented in the James River. Chesapeake Bay DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage, for the James River spawning population or for the DPS as a whole. The NEAMAP based methodology explained in Section 4.2 estimates a total of 8,811 subadult and adult CB DPS Atlantic sturgeon in the ocean.

We have estimated that the RoRo vessels associated with the marine terminal project will result in mortality of six Atlantic sturgeon, of which no more than one will originate from the Chesapeake Bay DPS. Given the very low number of adult CB DPS Atlantic sturgeon likely to occur in the action area, it is extremely unlikely that this one fish will be an adult. All other CB DPS Atlantic sturgeon in the action area are subadults. Therefore, we anticipate that if a Chesapeake Bay DPS Atlantic sturgeon is struck, it will be a subadult. We, therefore, consider the effects to the CB DPS from the loss of one subadult (>500mm TL <1,500 mm TL). Here, we consider the effect of the loss of this individual on the reproduction, numbers and distribution of the CB DPS.

The reproductive potential of the CB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of one female subadult would have the effect of reducing the amount of potential reproduction as any dead CB DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of one male subadult may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. Additionally, we have determined that any impacts to behavior will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The actions will also not affect the spawning grounds within the rivers where CB DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by CB DPS fish.

Because the action will result in the loss of only one individual, we do not expect this to change the status or trend of the Chesapeake Bay DPS as the loss is thought to represent a very small percentage of the population. The action is not likely to reduce distribution because the action will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the action area that may be used by CB DPS subadults or adults. Further, the action is not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area where noise levels are higher than 150 dB re 1uPa RMS.

Based on the information provided above, including the death of up to one CB DPS Atlantic sturgeon between now and the end of the project in 2047, the development and operation of the marine terminal will not appreciably reduce the likelihood of survival of the CB DPS (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of one subadult CB DPS Atlantic sturgeon is an extremely small percentage of the population and will not change the status or trends of the species as a whole; (2) the loss of one subadult will not result in the loss of any age class; (3) the loss of one subadult CB DPS Atlantic sturgeon will not have an effect on the levels of genetic heterogeneity in the population; (4) the loss of one subadult CB DPS Atlantic sturgeon between now and the end of 2047 will not have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of CB DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging CB DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the action will not appreciably reduce the likelihood that the CB DPS will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate.

We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this action will affect the likelihood of recovery of the CB DPS.

This action will not change the status or trend of the status and trend of the CB DPS. The action will result in a small amount of mortality (one subadult over 30 years) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because impacts to forage will be insignificant and effects on distribution are temporary and small. The action will not affect Atlantic sturgeon outside of the Delaware River and Delaware Bay or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon or the natal rivers of CB DPS origin Atlantic sturgeon. For these reasons, the action will not reduce the likelihood that the CB DPS can recover. Therefore, the action will not appreciably reduce the likelihood that the CB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the action, is not likely to appreciably reduce the survival and recovery of this species.

10.2.4 *South Atlantic DPS*

Individuals originating from the SA DPS are likely to occur in the action area. The SA DPS has been listed as endangered. We expect that 17% of the subadult and adult Atlantic sturgeon in the action area will originate from the SA DPS. Most of these fish are expected to be subadults, with few adults from the SA DPS expected to be present in the Delaware River. We expect that no more than 6 Atlantic sturgeon vessel mortalities and that no more than one of these will originate from the SA DPS. This fish are likely to be a subadult as juvenile SA DPS fish would not be present in the Delaware River.

No total population estimates are available for any river population or the SA DPS as a whole. As discussed in section 5.1.2, we have estimated a total of 14,911 SA DPS adults and subadults in the ocean (3,728 adults and 11,183 subadults). This estimate is the best available at this time and represents only a percentage of the total SA DPS population as it does not include young of the year or juveniles and does not include all adults and subadults. SA origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

The number of subadult SA DPS Atlantic sturgeon we expect to be killed due to the ongoing operation of the proposed marine terminal (1 over a 30-year period) represents an extremely small percentage of the SA DPS. While the death of 1 subadult SA DPS Atlantic sturgeon over the next 30 years will reduce the number of SA DPS Atlantic sturgeon compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this species as this loss represents a very small percentage of the SA DPS population of subadults and an even smaller percentage of the DPS as a whole. Even if there were only 11,183 subadults in the SA DPS, this loss would represent less than 0.0001% of the subadults in the DPS. The percentage would be much less if we also considered the number of young of the year, juveniles, adults, and other subadults not included in the NEAMAP-based oceanic population estimate.

Because there will be no loss of adults, the reproductive potential of the SA DPS will not be affected in any way other than through a reduction in numbers of individual future spawners as opposed to current spawners. The loss of one female subadults would have the effect of reducing the amount of potential reproduction as any dead SA DPS Atlantic sturgeon would have no potential for future reproduction. This small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. The loss of male subadults may have less of an impact on future reproduction as other males are expected to be available to fertilize eggs in a particular year. As none of the action area is within the SA DPS, the proposed action will 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 one subadult SA DPS Atlantic sturgeon over 30 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 one subadult SA DPS Atlantic sturgeon represents an extremely small percentage of the species; (2) the death of one SA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of one SA DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of one subadult SA DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the action will have only a minor and temporary effect on the distribution of SA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the action will have only an insignificant effect on individual foraging or sheltering SA DPS Atlantic sturgeon.

In rare instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce its likelihood of recovery. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon will survive in the wild, which includes consideration of recovery potential. Here, we consider whether the action will appreciably reduce the likelihood of recovery from the perspective of ESA Section 4. As noted above, recovery is defined as the improvement in status such that listing under Section 4(a) as "in danger of extinction throughout all or a significant portion of its range" (endangered) or "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range…" (threatened) is no longer appropriate. Thus, we have considered whether the proposed action will appreciably reduce the likelihood that SA DPS of Atlantic sturgeon can rebuild to a point where it is no longer in danger of extinction through all or a significant part of its range.

A Recovery Plan for the SA DPS has not yet been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. For Atlantic sturgeon, habitat conditions must be suitable both in the natal river and in other rivers and estuaries where foraging by subadults and adults will occur and in the ocean where subadults and adults migrate, overwinter and forage. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. Here, we consider whether this proposed action will affect the SA DPS likelihood of recovery.

This action will not change the status or trend of the SA DPS as a whole. The proposed action will result in a small amount of mortality (one subadult from a population estimated to have at least 11,000 subadults) and a subsequent small reduction in future reproductive output. This reduction in numbers will be small and the impact on reproduction and future year classes will also be small enough not to affect the trend of the population. The proposed action will have only insignificant effects on habitat and forage and will not impact the river in a way that makes additional growth of the population less likely, that is, it will not reduce the river's carrying capacity. This is because the impact to forage will be limited to temporary loss of prey in areas being dredged and most foraging occurs outside of the areas where dredging will occur. Impacts to habitat will be limited to temporary increases in suspended sediment during dredging and disposal and increased water depth; however, as discussed in the Opinion, we do not anticipate any changes to substrate type and to the salinity regime. We do not anticipate that any impacts to habitat will impact how sturgeon use the action area. The proposed action will not affect SA DPS of Atlantic sturgeon outside of the Delaware River or affect habitats outside of the Delaware River. Therefore, it will not affect estuarine or oceanic habitats that are important for sturgeon. For these reasons, the action will not reduce the likelihood that the SA DPS can recover. Therefore, the proposed action will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as endangered or threatened. Based on the analysis presented herein, the proposed action, is not likely to appreciably reduce the survival and recovery of this species.

10.2.5 *Carolina DPS*

As explained in section 5.1.2, 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 and based on mixed stock analysis, we considered the possibility that less than one percent (0.8%) 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 6 over a 30 year period) and the expected rarity of Carolina fish in the action area, it is extremely unlikely that any of the fish originating from the Carolina DPS that will be killed during the long term operation of the marine terminal. We do not expect any Carolina DPS fish to be present in the action area during the winter months when construction activities will be carried out; therefore, no Carolina DPS fish will be exposed to any effects of those activities. All other effects to Atlantic sturgeon, including habitat and prey, will be insignificant and discountable. Therefore, the action considered in this Opinion is not likely to adversely affect the Carolina DPS of Atlantic sturgeon.

11 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 shortnose sturgeon, or the GOM, NYB, CB, and SA DPSs of Atlantic sturgeon. We find that the proposed action is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon, or the Carolina DPS of Atlantic sturgeon, or North Atlantic green, Northwest Atlantic Ocean DPS loggerhead, Kemps Ridley sea turtles; or the North Atlantic right whale and fin whales.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. 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 regulation as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it 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.

Pursuant to section 7(b)(4) and section 7(o)(2), an incidental take statement (ITS) provides an exemption from the ESA section 9 prohibitions against take for an action agency and/or applicant, as appropriate, for effects caused by the action that meet the definition of "take," provided that the action is performed in compliance with the terms and conditions specified in the incidental take statement. Effects of the action are defined to include direct and indirect effects and the effects of interrelated or interdependent activities.

As explained in this Opinion, we anticipate that the construction and operation of the proposed marine terminal will result in 91 more large commercial cargo vessels transiting the Delaware River each year than currently occur. We anticipate that this will result in an increase in vessel strikes of shortnose and Atlantic sturgeon and that six Atlantic sturgeon (four New York Bight DPS, one Chesapeake Bay DPS or one from either the South Atlantic DPS or GOM DPS) and one shortnose sturgeon will be killed over the 30 year period that the marine terminal will be operational.

While the USACE is authorizing dredging and the construction of the in-water portions of the proposed marine terminal under their regulatory authorities, the USACE has indicated that they have no authority to regulate or control any of the vessels that may utilize the marine terminal over its 30-year life. Additionally, the applicant has indicated that while they can produce a reasonable estimate of the number of vessels that will utilize the marine terminal over its 30 year life, they cannot predict which vessels will use the terminal and that they have no means to regulate or control the operations of those vessels outside the marine terminal (i.e., along the transit route in the Delaware River where we expect vessel strikes to occur). Because it is these vessels that will cause the anticipated take, the vessel operators could be numerous, disparate and are of unknown identity, and neither the action agency nor the applicant have any authority to control these vessels, we are not exempting any take resulting from these vessels' transits. For the same reasons we are not including any reasonable and prudent measures or terms and conditions.

[26] http://www.nmfs.noaa.gov/op/pds/documents/02/110/02-110-19.pdf

Section 10(a)(1)(B) of the ESA authorizes NMFS, under some circumstances, to permit take otherwise prohibited by Section 9 of the ESA if such taking is "incidental to, and not the purpose of carrying out otherwise lawful activities." Non-federal parties may apply for a Section 10 incidental take permit to incidentally take listed species.

12.1 Amount or Extent of Take

The development of the proposed marine terminal will take place in locations where ESA-listed sturgeon under our jurisdiction will be present. We estimate that increased vessel activity that will not occur but for the construction of the proposed marine terminal will result in vessel strikes that kill six (6) subadult or adult Atlantic sturgeon and one (1) adult shortnose sturgeon over a 30-year period. No other take is anticipated. In the extent that any take occurs and is observed, it must be reported to NMS within 24 hours at incidental.take@noaa.gov.

12.2 Effect of Take

In Section 11, NMFS determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

12.3 Reasonable and Prudent Measures

None.

12.4 Terms and Conditions

None

13 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 USACE consider continuing to implement the following Conservation Recommendations that were recommended in previous Opinions:

1. The USACE should use its authority to require monitoring of underwater noise during the installation of a representative number of piles during each group of piles driven to confirm that attenuation measures works as assumed and that peak sound pressure does not exceed injurious levels. This will provide information to evaluate effects on sturgeon from future pile driving in the Delaware River and better assess the efficiency of measures implemented to avoid generating noise levels that could kill or injure these fish.

2. The USACE 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.

3. The USACE should use its authorities to support an ongoing sturgeon carcass tracking study by the Delaware State University. This would address the question of drift following mortality.

14 REINITIATION OF CONSULTATION

This concludes formal consultation on your proposal for the development of the Delaware River Partners Gibbstown Terminal and Logistic Center (CENAP-OP-R- 2016-0181-39**)**, as well as 30 years (through 2047) of operation of the terminal and logistic center. 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. If any take occurs and is observed, it must be reported to NMFS within 24 hours at incidental.take@noaa.gov.

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