NATIONAL MARINE FISHERIES SERVICE

ENDANGERED SPECIES ACT

BIOLOGICAL OPINION

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

Activity Considered: USACE Permit for the New Jersey Wind Port (NAP-2019-01084-39)

GARFO-2021-02227

Conducted by: National Marine Fisheries Service

Greater Atlantic Regional Fisheries Office

Date Issued: February 25, 2022

Approved by: ______________________________

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1 INTRODUCTION

This constitutes the biological opinion of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the consequences of construction and operation of the New Jersey Wind Port (i.e., NJWP or Port). The United States Army Corps of Engineers (USACE) is proposing to issue a 10-year permit under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act to Public Service Enterprise Group (i.e., PSEG or Applicant) for construction of the Port. The project will include development of a portion of the PSEG Nuclear LLC property along the Delaware River ("River") on Artificial Island in Lower Alloways Creek Township, New Jersey. The Port will serve as a marshalling facility in support of offshore wind projects in New Jersey and other U.S. East Coast states. The Port will serve as a location where major offshore wind components are delivered (from manufacturing centers), partially assembled prior to loading onto an installation vessel/barge, and shipped (vertically) to an offshore wind site. The USACE and the applicant have indicated that the typical life of an offshore wind development is 20 to 25 years. It is expected that the Port would support the initial development of multiple offshore wind projects and likely support some level of decommissioning for some of these same projects at a later time. The Applicant has stated that activities beyond 25 years are not included in the planning scope of this project due to anticipated technological advancements with equipment and installation methods.

This project involves both in-water and terrestrial activities needed to prepare the site for the above mentioned activities. Vessel traffic from the Port to the mouth of the Delaware Bay associated with the operation of the Port is also part of the action. Further, the applicant has developed a plan to mitigate for the loss 83.4 acres of benthic habitat within the dredge footprint at Artificial Island. The USACE requested formal consultation in a letter dated September 22, 2021. This Opinion is based on the information provided in the USACE's Biological Assessment (BA) enclosed with their letter dated September 22, 2021, which is the initiation date. The analysis, along with scientific literature and other sources of information as cited in the references section also contribute to the basis of this biological opinion. A complete administrative record of this consultation will be kept at our NMFS Greater Atlantic Regional Fisheries Office.

2 ESA CONSULTATION HISTORY

<u>November 2020 through June 2021</u>

We reviewed and commented informally on draft BAs, offering guidance on how to provide a complete and adequate analysis in the final BA to be submitted to us.

<u>June 2021</u>

On June 4, we received an email from the USACE requesting consultation under the ESA on the proposed action. The email included attached electronic copies of a signed letter requesting formal consultation and an associated BA.

On June 17, the Habitat and Ecological Services Division (HESD) in GARFO initiated conversations with the USACE about the need to mitigate for impacts to 83.4 acres of Essential Fish Habitat (EFH) within the dredging footprint at the project site.

On June 21, we informed the USACE via email that because the mitigation for impacts to EFH had not yet been determined, the action was therefore not finalized, and we did not have the information required to initiate consultation.

<u>July to September 2021</u>

We provided technical assistance to HESD and the USACE during the development of the compensatory mitigation plan and reviewed the updated BA once the edits were incorporated.

On September 22, we received an email from the USACE with an updated request for formal consultation. A signed electronic copy of a letter requesting formal consultation and an updated BA were attached with the email.

<u>October –November 2021</u>

On November 4, we sent an email to the USACE with an electronic copy of a letter dated November 4, 2021, initiating formal consultation. The initiation date was set to September 22, 2021, when we received the request for formal consultation with a BA with adequate information to initiate consultation.

3 PROJECT DESCRIPTION

The project includes the construction of the Port, the operation of the Port, and the implementation of a mitigation plan to compensate for dredging in a portion of the action area. Each of these three components and their related activities are described below.

3.1 Site Location

The proposed Port is located on the east bank of the Delaware River within the greater Estuary at approximately river kilometer (“RKM”) 84 (river mile [“RM”] 52), 24 km (15 mi) south of the Delaware Memorial Bridge. The Port will be constructed at the northwestern edge of the existing 734-acre PSEG property, which is the site of two power generation facilities, Salem Generating Station and Hope Creek Generating Station.[1] The proposed Port will occupy approximately 30 acres of the PSEG property, immediately to the

[1] PSEG’s Salem and Hope Creek Nuclear Generating Stations operate pursuant to licenses issued by the Nuclear Regulatory Commission. Incidental take of ESA-listed species as a result of these operations is exempted from Section 9 of the Endangered Species Act by an Incidental Take Statement (NER-2010-6581) issued by NMFS following the conclusion of formal ESA consultation on July 17, 2014. The Incidental Take Statement exempts take resulting from impingement or collection of sturgeon and sea turtles at the cooling water intake structure and from collection during routine biological monitoring. As a result of exceedances of the exempted take, formal consultation was reinitiated by the Nuclear Regulatory Commission on July 2, 2020 with the submission of a new BA for continued operation of Salem Generating Station (NRC 2020). Consultation is currently ongoing.

south of USACE Confined Disposal Facility Cell No. 3. The project site lies between the New Jersey shoreline and the Philadelphia to the Sea Federal Navigation Channel (Figure 1), located approximately 2,000 m (6,600 ft) west of the shoreline and maintained at approximately 14 m (45 ft) depth. The Artificial Island anchorage, General Anchorage No. 2, is located off the northern edge of Artificial Island, approximately 6 km (3.7 mi) upriver from the proposed Port.

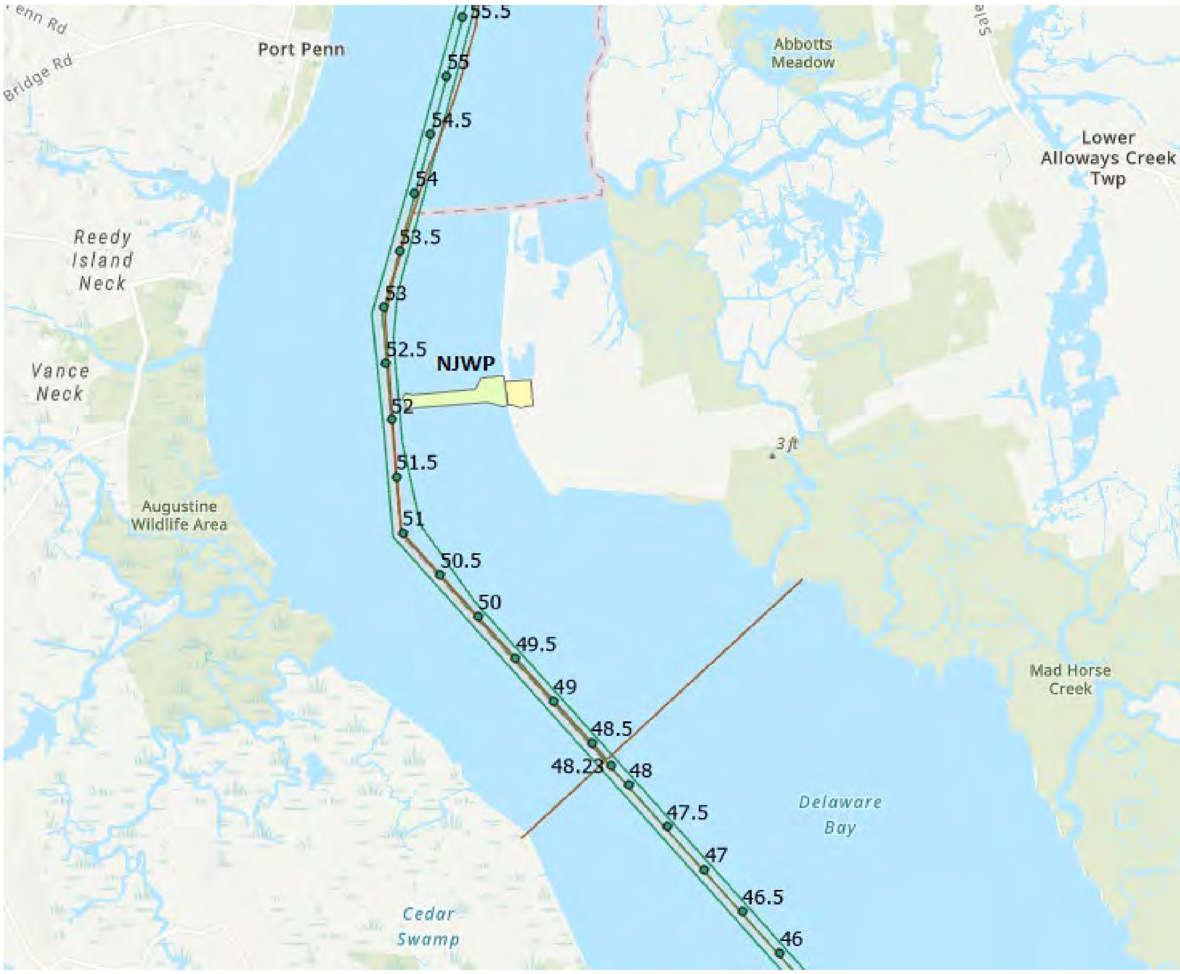


Figure 1. New Jersey Wind Port Development Boundary. The line across the channel is the location of the Delaware River mouth.

3.2 Port Facilities and Structures

The proposed Port will include a quay structure for vessel berthing (with an installation berth and a delivery berth), a landward laydown area, and staging and assembly buildings to support the deployment of offshore wind equipment. A steel sheet pile bulkhead will stabilize the shoreline with the quay structure extending from the bulkhead. Two mooring dolphins and one breasting dolphin in the northern section of the proposed Port site will support mooring of vessels. In addition, a submerged sheet pile/king pile wall will be installed in the water from the shoreline into the river to protect existing nearby submarine cables that extend from the shoreline.

3.3 Construction of Facility Structures

Before constructing the quay structure, the applicant will excavate approximately 320 meters (1,080 ft.) of shoreline behind an existing timber bulkhead to create an open water area. However, sheet piles will first be driven into the ground to establish an underground "wall" approximately 17 meters (m) (57 feet (ft)) inland from the existing timber bulkhead. The first purpose of the sheet pile wall is to provide structural support for the soil as the excavation could cause a failure with the subsurface soils that would cause the material to slide into the river. The sheet pile wall provides the subsurface stability during excavation and then would serve as the bulkhead for the new shoreline following shoreline excavation. Once the sheet pile wall is established, the existing timber bulkhead will be removed to facilitate shoreline excavation and creation of the new open water area. The old timber piles will be removed by cranes. Excavators, as part of the mechanical dredging, will remove any sections that may break off below the mudline.

The quay structure will be constructed of concrete and extend 17 m from the new bulkhead into the newly inundated area of the river where the old shoreline once was and approximately 91 m (300 ft) landward. The seaward face of the quay will align with the existing timber bulkhead at the shoreline such that the new quay structure will not encroach into the river beyond the existing shoreline. Riprap at a 1:3 slope extending just past the fender to a depth of 10.7 meters (35.5 ft) will protect the slope revetment beneath the overhang of the berthing platform. Immediately adjacent to the quay, an installation berth will be constructed along the northern portion of the structure, and a delivery berth will be constructed immediately to the south.

Two mooring dolphins and one breasting dolphin will be installed north of the installation berth in the northern section of the proposed Port site. The mooring dolphin platforms will be 5.8 m (19 ft) by 8.8 m (29 ft), and the breasting dolphin platform will be 8.8 m (29 ft) by 11.8 m (39 ft). The dolphins will adjoin to the installation berth via a 1.5 m- (5 ft-) wide elevated walkway, which will connect to each concrete dolphin platform.

A submerged sheet pile wall (rising approximately a foot or two above the bottom sediment) will be installed south of the quay structure in the water adjacent to the Silver Run submarine cable (Figure 2). The wall will extend 91 m (300 linear ft) from the shoreline into the river to protect the existing submarine cables from damage during dredging and displacement of sediment covering the cables caused by vessel activity at the Port.

Upland activities associated with the Port construction may result in erosion or stormwater runoff, which could affect water quality in the vicinity of the Project. A soil erosion and sediment control ("SESC") plan will be approved by the Cumberland-Salem Conservation District prior to the commencement of construction to minimize erosion and control stormwater runoff.

3.3.1 Pile Driving

Pile driving will be performed for construction of a new bulkhead, the quay structure, two mooring dolphins and one breasting dolphin, and submerged sheet pile/king pile wall. Pile driving will be conducted with both land-based equipment and three crane barges with tug support in-water. Piles for the bulkhead will be placed inland before excavation of the new open water area and only piles for the quay structure (in the new open water area), dolphins, and submerged sheet pile/king pile wall will be placed in water. Table 1 summarizes information about piles and pile driving for each structure. The quay structure will be supported by 2,000 30-inch square concrete piles. Of these, 650 will be driven in-water while the remaining will be driven in upland areas. The two mooring dolphins and one breasting dolphin located on the northern section of the Port will be supported by a total of thirty-four 30-inch square concrete plumb piles and 30-inch square concrete battered piles set at a 3:1 slope. The piles will be driven to an elevation of -103 ft NAVD88. The 91 m long submerged protective wall will consist of sheet piles and king piles as support. The king piles will consist of 12 to 24 inch H piles.

Pile driving is proposed to occur only during the in-water work window from July through March. As mentioned, pile driving will be conducted with land-based equipment, as well as three crane barges with tug support for local in-water movement of barges along the bulkhead. An impact hammer will be used for driving the piles for the quay structure and dolphins. A vibratory hammer will be used for driving piles for the submerged protective wall. Production pile driving for the wharf and landside foundations would occur over several periods:

- Sheet pile bulkhead installation (upland): June 2022 through July 2022
- Production piles (upland): May 2022 through January 2023 and July 2023 through December 2023
- Production piles (quay, in-water): September 2022 through December 2022
- Production piles (dolphins, in-water): September 2022 through December 2022
- Sheet pile wall (cable protection, in-water): January 2023 through February 2023

Each period would span approximately 40 to 80 days.

Table 1. Pile Driving Information. Table provided by the applicant.

Structure	Pile type	Hammer type*	Total Pile numbers***	Piles per day	Duration to drive piles (Individual pile or sheet))**
quay structure	30" square concrete pile	D-125 Diesel Hammer	650	4	60 minutes/pile
Two mooring and one breasting dolphins	30" square concrete pile	D-125 Diesel Hammer	34	2	60 minutes/pile
Submerged protective wall	24" steel sheet pile	APE-150 Vibratory Hammer/D-120 Diesel Hammer	128	8	15 minutes/sheet
Submerged protective wall	16 and 18 Steel H pile (as king piles)	APE-200 Vibratory Hammer/D-120 Diesel Hammer	37	6	30 minutes/sheet

* King and Sheet pile walls will be installed utilizing a vibratory hammer. An impact hammer may be utilized if obstructions are encountered or suitable depth is not reached via vibratory methods.
** Concrete piles will be installed utilizing water jetting with final 10-20 feet of driven depth utilizing an impact hammer. Pile driving duration are estimates and is likely to fluctuate.
*** Total number of piles provided are piles or sheet/king piles installed in water. Total does not include upland piles or sheets.

3.4 Construction of Berth, Turning Basin, and Access Channel

The Applicant will construct two berthing areas in the river immediately adjacent to the quay structure, including an installation berth measuring 146 m (479 ft) long and a delivery berth measuring 183 m (599 ft) long (Figure 2). An area of 137 m (450 ft) by 76 m (250 ft) will be dredged to an elevation of -35.5 ft NAVD88 with an additional 3.7 m (12 ft) of overdredge. The area will then be filled with crushed gravel to an elevation of -35.5 ft NAVD88 to bring it to grade with the surrounding riverbed. The gravel will provide a stable, hard-bottom foundation to support a jack-up installation vessel during loading and unloading of offshore wind components at the Port.

A turning basin will be dredged in front of the berth and quay structure and will provide a 1,050-foot diameter circular turning area for vessels (Figure 2). The turning basin will be dredged to the same depth and over-dredge as the approach channel.

The approach channel will measure approximately 168 m (550 ft) wide and 1,524 m (5,000 ft) long and would be dredged to a depth of -35.5 ft NAVD88 with an estimated overdredge of -0.5 m (-1.5 ft) for a total potential dredge depth of -37 ft NAVD88 (-34 ft MLLW). The approach channel will interface with the existing navigational channel within the Baker Range, at approximately RKM 84 (RM 52). The depth of the adjacent navigational channel is -45 ft MLLW. The footprint of the approach channel ends approximately 91 m (300 ft) from the toe of the navigational channel side slope. Dredged material will be disposed of in the current USACE Confined Disposal Facility Cell No. 3 located on Artificial Island adjacent to and just north of the proposed Port.

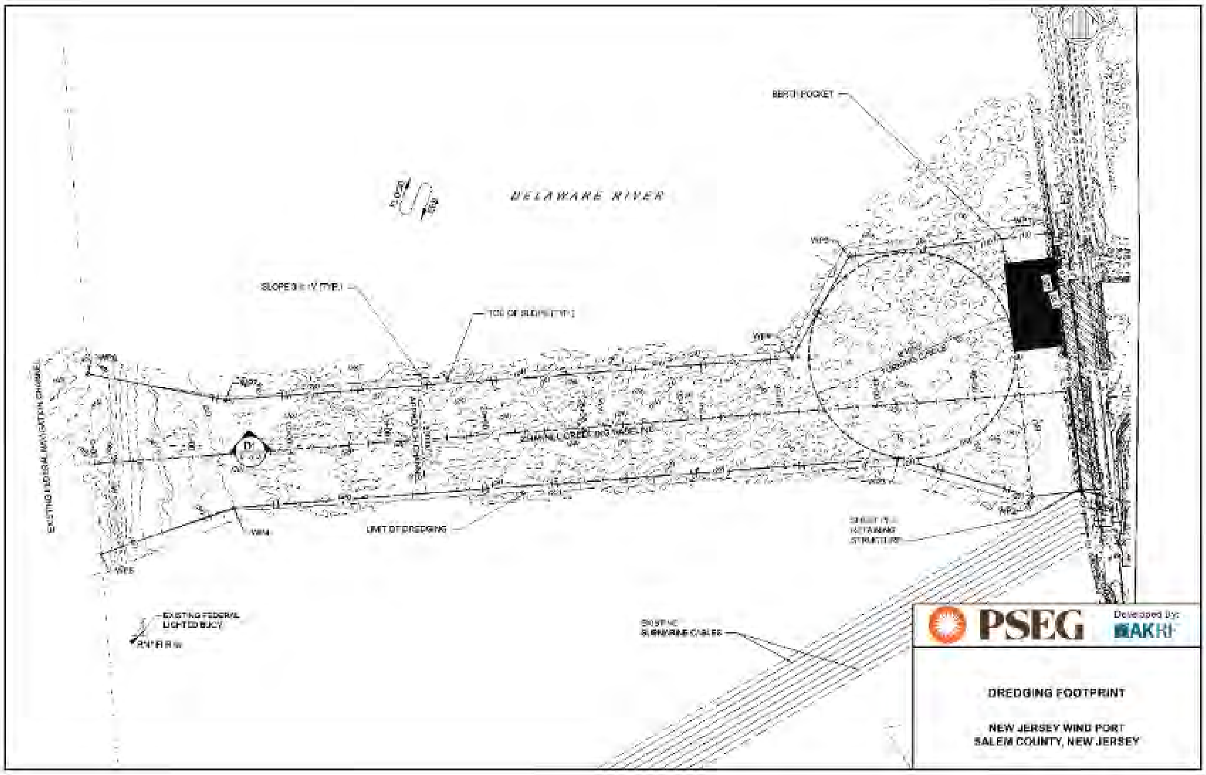


Figure 2. Dredging Footprint (USACE 2021).

3.4.1 Dredge Types

A cutterhead hydraulic dredge will be required to create an approach channel, vessel turning basin, and berthing areas for the ocean-going delivery and wind turbine installation vessels to access the quay. Throughout the planned dredge footprint, water depths currently range from 3.7 to 10 m (12 to 32.5 ft) Mean Lower Low Water (MLLW). A small area near the sheet pile bulkhead will be dredged with a mechanical clamshell dredge. Mechanical dredging will also be used to create approximately 329 m (1,080 ft) of the new shoreline located and filled approximately 57 ft landward behind the existing timber bulkhead for construction of the quay structure.

3.4.1.1 Mechanical Bucket Dredge

The mechanical bucket dredge utilizes a bucket to excavate sediments. The sediments are placed in scows or hopper barges that are towed or pushed to the dredged material placement site. Bucket dredges include clamshell, orange-peel, and dragline types. The crane that operates the bucket can be mounted on a flat-bottomed barge, on fixed-shore installations, or on a crawler mount. In most cases, spuds, or anchors in conjunction with spuds are used to position the plant. Dredging is suspended when a barge is fully loaded, moved away, and replaced with another empty scow or barge. Dredging may resume once a new empty barge/scow is in place. The opening of the bucket is controlled by the closing and hoisting wires or by hydraulic cylinders. The bucket is lowered into the water and is opened to grab the substrate. Only a small area is impacted at any given time and the bucket is lifted up and emptied between each grab.

3.4.1.2 Hydraulic Cutterhead Pipeline Dredges

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

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

Cutterhead suction dredges are equipped with a rotating cutterhead, which is able to cut hard substrates or rock into fragments, and is mounted in front of the suction head and rotates along the axis of the suction pipe. The cutterhead is buried into the bottom substrate while the dredge pump suctions in the sediments within the dredging footprint. A floating pipeline transports the sediment/water slurry from the cutterhead to a disposal site or onto a barge.

3.4.2 Dredging Acreage, Volume, and Timing

Dredging will occur within an 86-acre area adjacent to the steel sheet pile bulkhead described above. Proposed activities include:

1. Excavation (via mechanical clamshell dredge) of approximately 4.1 acres to create the new shoreline and the delivery and installation berths. This includes the area 57 ft landward (approximately 1 acre) behind the existing timber bulkhead to create the new shoreline for the quay structure.
2. Dredging (mostly by hydraulic cutterhead dredge) of approximately 81.1 acres of the existing riverbed for the access channel, turning basin, and berths excluding the landward excavation area. Of this, approximately 63 acres of riverbed will be dredged for the access channel alone.

Approximately 1,960,000 cubic yards (CY) will be dredged for construction of the Port, which was calculated based on hydrographic data obtained in January 2020 by S. T. Hudson Engineers, Inc. Of this, approximately 170,000 CY will be removed via mechanical dredge and 1,790,000 CY will be removed by hydraulic dredging (Table 2). As mentioned above, a cutterhead hydraulic dredge will be used to create the approach channel, vessel turning basin, and berthing areas for vessels to access the quay. The area immediately adjacent to the sheet pile bulkhead will be dredged with a mechanical clamshell dredge. Dredging would occur within an area of 86 acres. This dredge footprint would include excavation 57 feet landward behind the existing timber bulkhead to create the new shoreline for the quay structure. Excluding the landward excavation area, the dredge footprint occupies approximately 85 acres of the existing riverbed.

Table 2 shows the periods when dredging for each project component will occur. The mechanical dredging of approximately 179,000 CY to create the shoreline slopes adjacent to the sheet pile bulkhead of the installation and delivery berths will occur over a three- to a four-week period during July and September 2022. The first stage of hydraulic dredging will overlap with mechanical dredging during a 35-day period between July 1 and the end of September 2022. During this stage, approximately 850,000 to 900,000 CY of material will be dredged from the berthing areas and channel approach. The second stage of hydraulic dredging will occur for approximately 75 days between July 1 and the end of September 2023 and will remove approximately 850,000 to 900,000 CY of material to construct the access channel for the proposed port.

Table 2. Estimated volume and acres to be dredged in total and for different components.

Area	**Dredge**	**Acreage**	**Cubic Yards**	**Duration**	**Period**	**Disposal**
Total: All dredging (including landward excavation)	Hydraulic/Mechanical	~85.9	~1,960,000	3 to 4 weeks	2022 and 2023	AI CDF* Cell No.3 and PSEG Nuclear CDF
- first period	Hydraulic and Mechanical	~52.3	~1,065,000	3 to 4 weeks	July to Sept 2022	AI CDF Cell No.3 and PSEG Nuclear CDF
- second period	Hydraulic	~33.6	~895,000	3 to 4 weeks	July to Sept 2023	AI CDF Cell No.3
Landward (area behind existing timber bulkhead)	Mechanical	~1		3 to 4 weeks	2022	AI CDF Cell No.3 and PSEG Nuclear CDF
Berths	Mechanical	~3.1	170,000**		July to Sept 2022	AI CDF Cell No.3 and PSEG Nuclear CDF
Approach Channel, Turning Basin	Hydraulic	~81.8	~1,790,000		2022 and 2023	AI CDF Cell No.3
Stage 1	Hydraulic	48.2	850,000 to 900,000	3 to 4 weeks	July to Sept 2022	AI CDF Cell No.3
Stage 2	Hydraulic	33.6	850,000 to 900,000	3 to 4 weeks	July to Sept 2023	AI CDF Cell No.3

*Artificial Island CDF

** Includes material dredged landward behind the existing timber bulkhead

3.4.3 Dredged Material Disposal

PSEG will make every effort to identify and implement beneficial reuses for dredge spoils from both hydraulic and mechanical dredging. Material that PSEG cannot beneficially reuse will be disposed of in the current USACE Confined Disposal Facility (CDF) Cell No. 3 located on Artificial Island adjacent to and just north of the NJWP site. Hydraulic dredge operations will pipe the dredged material directly to the above mentioned disposal site. Dredged material from mechanical dredging will be transferred to a scow or hopper barge and towed a short distance to the disposal area, where hydraulic equipment will unload the material. All dredged material will be placed at permitted upland sites. Therefore, the effects of placement will not be considered further.

3.5 Project Vessels and Vessel Traffic

3.5.1 Vessel Traffic during Construction

As previously noted the vast majority of dredging will occur with a hydraulic dredge which will likely be self-propelled. However, the contractor could choose to utilize a barge mounted hydraulic dredge which will require tugboat assistance. Support barges, if needed, will also require tugboat assistance. Mechanical dredging activities utilize a barge mounted clamshell dredge and scows/barges. These vessels all require tugboat assistance.

To be conservative, we assume that five non self-propelled vessels and three self-propelled vessels will be used during construction (Table 3 and Table 4). The maximum number of dredging vessels operating at a given time will include one cutterhead hydraulic dredge and one clamshell dredge, and both will be accompanied by two to three scows or hopper barges to contain the dredged materials. Dredging vessels will remain in the vicinity of the proposed Port for the duration of dredging activities and will not regularly transit the Delaware River. Dredging vessels will only transit the River twice during each dredging period, once during the one one-way trip to the proposed Port site and again during the one one-way trip departing the proposed Port site. During construction, project-related vessels traveling within the access channel between the Federal Navigation Channel and the site of the proposed Port wills limit speeds to 10 knots or less.

Table 3. Non self-propelled vessels.

Activity	Vessel	Number	Periods	Duration
Dredging for access, turning basin, and berth	cutterhead hydraulic dredge	1	Jan to March July to Nov	35 days 75 days
Dredging for installation and delivery berths	clamshell dredge	1	Aug to September Jan to March	21 days 28 days
Dredging for Installation and delivery berths	scows or hopper barges	3	Aug to September Jan to March	21 days 28 days

Table 4. Self-propelled vessels.

Activity	Vessel	Number	Periods	Duration
Dredging for access, turning basin, and berth	Tug – support hydraulic dredge	1	Jan to March July to Nov	35 days 75 days
Dredging for installation and delivery berths	Tug – support mechanical dredging	1	Aug to September Jan to March	21 days 28 days
Dredging for Installation and delivery berths	Tug – support scows and hopper barges	1	Aug to September Jan to March	21 days 28 days

It will be necessary to use vessels for installation of the quay, dolphins, and pile wall. The anticipated vessel spread for installation work will consist of up to two tugs used for moving barges and scows and for delivering materials to the project site and four to six barges for pile driving and material storage. Construction vessels will be up to 36.6 m (120 ft) in length, with a maximum draft of 6 m (20 ft). Construction vessels will operate in the project area 6 days per week, up to 12 hours per day during a July 1 to March 15 in-water work window over a two-year construction period. During pile driving, vessels will operate within the Project area for up to 12 hours per day, 6 days per week, and there will be up to three barges working simultaneously.

Deliveries of construction material (e.g., concrete piles, steel sheet piles, deck panels) are expected to occur two to three times per week via tug-assisted barge (i.e., 3 round trips to and from the construction site, or 6 one-way vessel trips per week). Only one delivery barge, and accompanying tug will be in the project area at any given time. It is expected that delivery barges will travel from an upriver contractor yard to the barge slip at Hope Creek Nuclear Plant, adjacent to the proposed Port. Vessel deliveries along this route would cover a one-way distance of up to 129 RKM (80 RM) and would occur weekly over the two-year construction period. Pile driving vessels will remain in the Project area throughout the duration of pile driving activities and will not contribute to increased vessel traffic in the River. Approximately 312 delivery vessel trips annually (i.e., up to six one-way vessel trips per week) will occur.

3.5.2 Vessel Traffic during Port Operation

The USACE and the applicant have stated in several calls and emails that the NJWP will only provide services for the development of offshore lease sites. Further, in the BA, it is stated that vessel traffic associated with projects unrelated to offshore wind development cannot be predicted as such uses of the proposed NJWP have not been identified. However, no vessel activity at the Port will occur when the Port is not commissioned and being used in support of an offshore wind project. Thus, this biological opinion only evaluates the effects of vessel traffic associated with offshore wind development projects.

Vessel traffic will be intermittent over the 25-year life of the Port and will be associated with the construction of several different offshore wind projects. The exact number of offshore wind projects that will use the Port is not yet known; however, there are currently

14 offshore lease areas under development between Cape Cod and Cape Hatteras, and approximately 19 offshore wind projects at various stages of planning. Additional future wind farm projects beyond those currently planned are likely to be proposed. However, the USACE and applicant expect that the number of vessel calls associated with potential future wind projects will be similar to the expected number of vessel calls associated with existing planned projects. In other words, the number of vessel calls at the port will remain constant throughout the expected 25 years of operation.

While it is expected that the NJWP will serve the offshore wind developments between Cape Cod and Cape Hatteras, to our knowledge, the applicant has not entered into a contract with any single wind development project, thus the exact lease sites that the NJWP will support is unknown. Further, while it is expected that the NJWP will continue to serve future projects, the offshore location of these are also not known at this time. However, we can be reasonably certain that vessels calling at the NJWP will transit between the pilot boarding area just offshore of the Delaware Bay mouth and the Port. Therefore, we only consider the consequences of vessel traffic in the action area between the pilot boarding location and the proposed Port.

Two types of vessels are expected to utilize the NJWP: wind turbine installation vessels and delivery vessels. Installation vessels for offshore wind projects are expected to range in size from approximately 145 m (475 ft) to 152 m (500 ft) in length with a draft of approximately 8.5 m (28 ft). Offshore delivery vessels are expected to be approximately 180 m (590 ft) in length with a draft of approximately 9.1 m (30 ft). Tugboats maneuvering installation and delivery vessels are expected to be up to approximately 32 m (105 ft) in length with a draft of approximately 5.5 m (18 ft). During transit to and from the Port, installation and delivery vessels will travel at speeds of 10 to 20 knots in the navigation channel, but will travel at 2 to 3 knots through the access channel and when approaching the berthing area. Once the vessel is moored along the quay for loading and/or unloading, the vessel will remain stationary until departing for its next offshore trip.

During operations at the Port, vessels will deliver materials from supply chain facilities along the coast and subsequently deliver fabricated components to the offshore wind facilities under construction in one or more of the offshore lease areas. Once commissioned, a three- to four-month preparation period will be needed, during which offshore wind farm components will be stockpiled and staged at the Port. During the preparation period, it is estimated that 10 to 12 delivery vessel trips will occur each month for a total of up to 48 vessel trips annually (i.e., 96 one-way delivery vessel trips per year). During the six to eight month wind farm construction period, approximately four installation vessel trips and up to 10 delivery vessel trips are expected per month, which is approximately 112 vessel trips (i.e., 224 one-way trips) per year per project. Between the preparation and construction periods, up to 160 vessel trips (i.e., 320 one-way trips) are expected per year (Table 5).

Tugs will be used during all berthing of delivery and installation vessels at the Port. The USACE estimates that all vessels will be accompanied by three tugs, therefore, approximately 960 one-way tug trips are expected to be associated with Port operation, resulting in a total of 1,280 one-way vessel trips annually during operations (Table 5).

Table 5. Annual Vessel Traffic Expected during Port Operation.

Vessel Type	Draft	Number of Trips[1]
Delivery Vessel	9.1 m (30 ft)	256
Installation Vessel	8.5 m (28 ft)	64
Sub-total - Offshore Wind Vessels		320
Tugs	5.5 m (18 ft)	960
Total - All Vessels		1,280

[1] One way trips

3.6 Ballast Water

Offshore delivery and installation vessels traveling to and from the proposed Port may withdraw or discharge ballast water to ensure proper operation and stability of the vessels.

Ballast intake pumps are expected to be similarly sized as vessels currently operating in the Delaware River. Literature review of vessel types indicates a wide range of flow rates for ballasting systems and specifics for the vessels likely to call at the NJWP is not known. However, the applicant has indicated that a flow rate of 2,000 m^3/h for barges and general cargo vessels is reasonable. Vessel ballast intakes are screened to minimize entrainment of aquatic organisms; typical screen openings are approximately 10 mm.

Ballast water discharges will be made in compliance with United States Coast Guard (USCG) ballast water exchange regulations (33 CFR 151.1510) and the United States Environmental Protection Agency's (EPA) Vessel General Permit program to avoid introduction of invasive species through discharged ballast water. During regular port operations, offshore delivery and installation vessels could potentially discharge or release oil, fuel, or waste. Such a discharge or release would be accidental and is considered unlikely. Vessels will need to implement measures in accordance with approved plans to avoid discharges and minimize consequences should any discharges occur.

3.7 Compensatory Mitigation Project

3.7.1 Background

As part of the USACE permit for the NJWP the USACE is requiring mitigation for the loss of 83.4 acres of benthic sandwave habitat within the dredge footprint at Artificial Island. Dredging of the approach channel, turning basin, and berthing area will result in the loss of 83.4 acres of sand-wave habitat, which has been identified by HESD as Essential Fish Habitat ("EFH") for some fish species in the Delaware River estuary. The mitigation is described in the final mitigation plan provided to us with the request for formal consultation on September 22, 2021.

To evaluate the efficacy of the mitigation plan as habitat for fish and shellfish, biological and habitat monitoring will be conducted at the mitigation site before and after placement of the wave structures. Pre- and post-mitigation monitoring includes fish sampling, benthic surveys, and measurements of current velocity. Fish sampling methods will be selected to avoid take of federally-listed species. This consultation will have to be reinitiated if methods are used that may affect listed species under our jurisdiction.

3.7.2 Proposed Mitigation

Concrete structures mimicking the structurally complex habitat provided by naturally occurring sand waves will be placed on the substrate in the River to the south of the site in order to mitigate for the loss of benthic habitat (Figure 3). The concrete structures are approximately 3 m (10 ft) in length, 1.2 m (4 ft) in width, and 1.2 m (4 ft) in height with a maximum footprint of 3.7 m^2 (40 ft^2 [10 ft long by 4 ft wide]). The concrete structures will be placed end-to-end on the substrate to resemble sand waves. Each artificial wave will be approximately 61 m (200 ft) in length and placed with a 7.6 to 15.2 m (25 to 50 ft) space between each wave. Thus, the each artificial wave has a footprint of approximately 74.3 m^2 (800 ft^2). The waves will be oriented in the prevailing direction of the tidal flow and river current and will be placed in groups of three waves. Seventeen groups of three waves each will be placed at the mitigation site (Figure 4). Therefore, the structures will have a total footprint of approximately 3,790 m^2 (40,800 ft^2 = 51 waves total x 800 ft^2 per wave]) or 1 acre, which is equivalent to less than 1% of the existing benthic habitat within the 120-acre mitigation site.

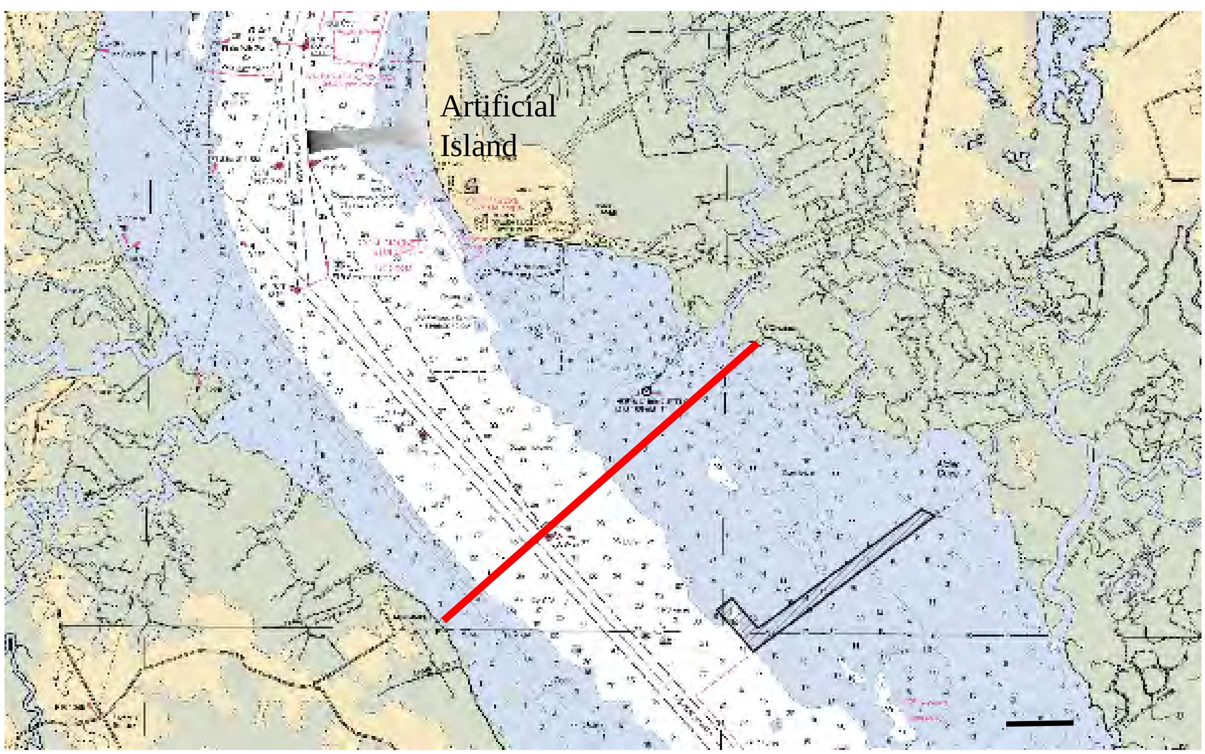


Figure 3. Location of the compensatory mitigation site for soft-bottom enhancement (shown by black box) (USACE 2021).

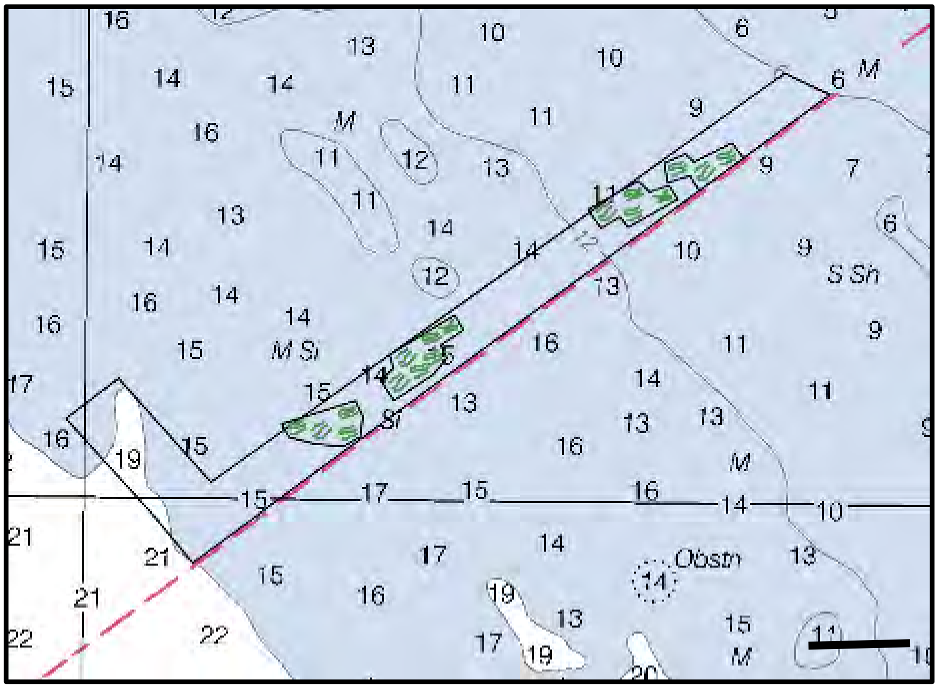


Figure 4. Rendering of the compensatory mitigation site. Green lines indicate the locations and configuration of concrete "wave" structures and black polygons depict the groups of wave structures.

3.8 Best Management Practices

During construction and operation of the proposed Port, PSEG has committed to measures to avoid, minimize, or mitigate adverse impacts to threatened and endangered species in the action area. These measures, which will be required Best Management Practices or permit conditions in the USACE permit for the Project, address impacts due to increased vessel traffic, dredging, and pile driving:

- Vessel speed restrictions to reduce the risk of vessel strikes
  - During construction, Project-related vessels traveling within the access channel between the Federal Navigation Channel and the site of the proposed Port will limit speeds to 10 knots or less. Such a speed restriction has been previously utilized as an avoidance/minimization measure in the Delaware River (NMFS 2017a).
  - During operation of the proposed Port, installation and delivery vessels will travel at 2 to 3 knots when transiting between the Federal Navigation Channel and the proposed Port on approach to the berthing area (Section II.C). These vessels will also be restricted to traveling at or below 2 to 3 knots between the proposed Port and the Federal Navigation Channel when leaving the berthing area.
- Timing restrictions for in-water work
  - Dredging will be conducted only during the in-water work window from July 1 to March 15 to avoid impacts to spawning sturgeons.

    - In-water work for compensatory mitigation will be conducted only during the in-water work window from July 1 to March 15 to avoid impacts to spawning sturgeons. Timing of concrete structure placement will also be scheduled during the period from July 1 to March 15.
- Protected species monitoring during in-water mitigation activities
    - Prior to the daily placement of concrete structures for the compensatory mitigation project, sonar surveys will be conducted to confirm that sturgeons are not resting on the bottom in the placement area, avoiding or minimizing the risk of physical interaction between the concrete structures and sturgeons during mitigation project construction.
    - If in-water mitigation activities occur when sea turtles may be present (i.e., July through November), protected species observers will monitor for the presence of sea turtles at the mitigation site to avoid or minimize the risk of physical interaction between the concrete structures and sea turtles during mitigation project construction.
- Dredging best management practices
    - A small-diameter (30-inch) cutterhead will be used for all hydraulic dredging for the proposed Port. The use of a cutterhead of this size has been utilized as a best management practice for reducing entrainment risk (NMFS 2019b).Though the risk of sturgeon entrainment during cutterhead dredging activity is low, entrainment of shortnose sturgeon has been documented when such dredging equipment is in use, and Atlantic and shortnose sturgeon may be found in the action area during the in-water work window. Therefore, a side-scan sonar will be used prior to the start of dredging to determine if any fish identifiable as sturgeon are present in the proposed dredge area. Sturgeon would be identified based on large body size, heterocercal tail, and proximity to the riverbed. In the event that dredging is momentarily discontinued (e.g., during a shift change, lunch break, equipment maintenance, etc.) for a period of more than 60 minutes, the area to be dredged would be surveyed prior to resuming the activity to determine if any sturgeon are present. If one or more sturgeon are observed, an alternate area would be surveyed and, if none are observed, dredging would commence there. In addition, a Protected Species Observer will be used at the confined disposal facility during dredging to monitor for any occurrences of sturgeon entrainment.
    - To reduce suspended sediment concentrations and entrainment of fish associated with cutterhead dredging, dredge operation will only start after the head is placed in the substrate and all suction associated with the active dredging will be terminated prior to lifting the dredge head from the substrate.
    - A turbidity curtain will be used during mechanical dredging as practicable where water depths and current velocities allow for effective deployment and operation. For the purposes of the effects analysis (Section V), we assume the worst-case scenario that utilization of a turbidity curtain is not practicable.

    - Additional measures to be included as USACE permit conditions to minimize the risk of physical interactions with the mechanical dredge and reduce suspended sediment concentrations associated with mechanical dredging will be implemented, including controlled entry and exit of the bucket and allowing water to drain from the bucket prior to depositing spoils in the scow.
- Pile driving best management practices
    - A cushion block will be used during impact pile driving to reduce underwater noise levels produced during installation of in-water piles.
    - A soft start will be used at the initiation of impact driving for each pile, allowing listed species to leave the action area prior to the production of maximum noise levels, reducing the risk of injury. Pile driving at the start of each day will commence with an initial set of three strikes with the hammer operating at 40% power. After a one-minute pause, two more sets of three strikes separated by a one-minute pause will be performed with the hammer operating at 40% power. After a third and final one-minute pause, normal hammer operations will commence.
- Ballast water best management practices
    - Vessel ballast intakes will be screened to minimize entrainment of aquatic organisms from the River.
    - Vessels transiting to and from the proposed Port during operation will be required to comply with the EPA's Vessel General Permit program and with USCG ballast water exchange regulations specified at 33 CFR 151.1510 to avoid introduction of invasive species to the action area through discharge of ballast water.
- Erosion and stormwater best management practices
    - Silt fences and silt socks will be used during adjacent upland activities associated with construction of the proposed Project to prevent sediment-laden runoff from entering the River.
    - Rock construction pads will be used in adjacent upland areas during construction of the proposed Project to limit transport of material outside the work zone (where silt fences and socks will be utilized) by vehicles entering and exiting the work zone.
    - Secondary containment devices will be used for all stationary equipment and storage areas containing petroleum or other hazardous materials.
- Mitigation monitoring best management practices
    - Biological monitoring to evaluate the efficacy of compensatory mitigation will use sampling methods that avoid take of federally-listed species at the mitigation site (i.e., sea turtles and sturgeons). Such methods may not include gill net or trawl sampling.

The following measures will be implemented to monitor for impacts and effects:

- Habitat Monitoring

    - Monitoring upstream and downstream of the dredging access channel and berthing area to evaluate potential impacts to adjacent habitats to develop our understanding of impacts (i.e., extent of impacts, scope).
- Vessel call reporting
    - During construction and operation of the proposed Port, the annual number of vessel calls to the proposed Port will be documented and reported to USACE.

4 ACTION AREA

The action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR§402.02). For this project, the action area is determined by construction activities, vessel traffic during construction and operation of the NJWP, and stressors associated with these activities. In total, the action area occupies approximately 51,732 acres, including the 530-acre project area adjacent to the proposed port that will be directly and indirectly affected by construction activities (dredging, pile driving, and movements of project vessels), and the approximately 120-acre mitigation site (Table 6). In addition, the action area includes the transport by tug supported barges of construction materials from upstream contractor yards to the barge slip at Hope Creek Nuclear Plant and the travel of vessels during port operation. Construction materials may be sourced as far as 120 km (80 miles) upstream of the project site. During operation of the Port, vessels will travel between the Pilot Area at the mouth of the Delaware Bay and the Port. We expect all vessels will travel within the federal navigation channel during transit. Thus, the action area includes the Philadelphia to Trenton federal navigation channel, the Philadelphia to the Sea federal navigation channel, the precautionary area at the mouth of the Delaware Bay, and the pilot area. This encompasses an area estimated to be 51,202 acres.

Specifically, the in-water dredge footprint for the proposed project (including the berthing area, turning basin, approach channel, and quay) encompasses 85 acres. As upland disposal of dredged material is proposed, no additional in-water areas will be affected by disposal activities. The action area also includes where underwater noise will ensonify the waterbody during pile driving. Based on the NOAA Fisheries GARFO Acoustic Tool, biologically significant sound levels could extend as far as 90 m from the piles being driven. Turbidity plumes associated with dredging are expected to extend further than the ensonified area. The sediment plume could extend up to 500 m from the cutterhead dredge, and up to 732 m from the mechanical dredge, which will operate near the shoreline, only. In total, the portion of the action area where dredging (including sediment plumes), vessel traffic between the

Federal Navigation Channel and the proposed Port, and pile driving is proposed, occupies approximately 530 acres.[2]

The action area also includes the 80- to 120-acre mitigation site required for compensatory mitigation. Of this, the placement of habitat structures will cover approximately one acre of bottom substrate. Vessels will travel in the Federal Navigation Channels during construction and operation of the Port and may affect listed species. The Federal Navigation Channel from Trenton to the Sea stretches from approximately RKM 214.5 to RKM 8, and encompasses an area estimated to be 11,568 acres (NMFS 2019). The portion of the Philadelphia to the Sea Federal Navigation Channel where offshore installation and delivery vessels will transit when traveling to and from the proposed Port during operation includes the length of the Federal Navigation Channel from its intersection with the Port access channel at approximately RKM 85 (RM 53) to its end in Delaware Bay at approximately RKM 8 (RM 5). This constitutes approximately 9,505 acres. Additionally, the action area includes all areas between the end of the Federal Navigation Channel and the pilot boarding area east of Cape Henlopen, Delaware at approximately RKM 0 (RM 0), including the regulated Precautionary Area, encompassing approximately 39,634 acres. It also includes the pilot boarding area.

Table 6. Acreage of different sections of the action area.

SECTIONS	BASIN AREA	RKM (RM)	STRESSORS	ACRES
Project Area	Delaware River	85.3 (53) to 83.7 (52)	Dredge capture, turbidity, sound, habitat modification	530
Federal Navigation Channel	Delaware River and Bay	214.5 (133) to 8 (5)	Vessel Traffic	11,568
Precautionary Area and Connecting Channel	Delaware Bay	8 (5) to 0	Vessel Traffic	37,034
Pilot Area	Atlantic Ocean	N/A	Vessel Traffic	2,600
Mitigation Site	Delaware Bay	TBD	Habitat modification	120

4.1 Environmental Conditions and Habitat in the Action Area

The biological assessment reviewed the environmental conditions of the Delaware River at the project site. We have utilized most of the information provided in the BA, and have added information where necessary in order to support a complete and thorough effects analysis below.

[2] This acreage may be an overestimate of the size of the area impacted by construction and construction activities as this calculation includes circular areas affected by sediment plumes. In reality, sediment plumes would have an oblong shape. However, as the direction of the plume would be influenced by tidal conditions, circular areas were utilized to capture all possible drift directions and represent a worst-case scenario.

The Project site lies between the New Jersey shoreline and the Philadelphia to the Sea federal navigation channel located approximately 2,000 m (6,600 ft) west of the shoreline and maintained at approximately 14 m (45 ft) deep. Water depths in the General Anchorage No. 2, located approximately 6 km (3.7 mi) upriver from the proposed Port, range from 6 m (21 ft) to 12 m (39 ft). Throughout the planned dredge area, east of the federal navigation channel, water depths range from approximately 4 to 10 m (12 to 32.5 ft) MLLW.

Bottom substrate in the project area is composed primarily of fine-grained silts, clays, and fine sand. Sutton *et al.* (1996) characterized the reach of the river or the NJWP site as the null zone where downstream sediment transport is countered by tidal propagation from the sea (through Delaware Bay).

4.1.1 Flow and Tides

The reach of the River where the proposed Port is to be located is tidal, though the net flow is downriver (i.e., south). Tides in this portion of the River are semi-diurnal with a period of 12.4 hours. The average tidal range in this region is 1.7 m (5.5 ft) (USNRC 2010).

4.1.2 Water Quality at Project Site

4.1.2.1 Salinity

The proposed Port is located at 84 RKM (RM 52) in what is characterized as the mesohaline (5 to 18 ppt) zone with variable salinity in this tidal portion of the river. Based on specific conductivity data gathered at Reedy Island approximately 4.8 km (3 mi) upstream of the proposed Port, monthly average salinity from 2015 to 2019 varied between 1.9 and 7.9 ppt (USGS 2020). The monthly minimum salinities were near 0 ppt throughout the year, and maximum salinities ranged from 8.4 to 16.2 ppt (USGS, site no=01482800, https://waterdata.usgs.gov/). The Delaware Bay is polyhaline (18-30ppt) with increasing salinity closer to the mouth of the Bay. The pilot area is located in marine waters outside of the Bay. However, while in marine waters, the nearshore coastal water at the Bay mouth normally has lower salinities than the surrounding marine waters.

4.1.2.2 Water Temperature

Surface water temperature data collected from the United States Geological Survey (USGS) gage (USGS 01482800) at Reedy Island indicates that monthly average water temperatures from 2009 to 2018 ranged from 2.7°C (36.9°F) in January and February to 27.7°C (81.9°F) in July (USGS 2022) (see Table 7). Minimum temperatures were lowest in January and February at -0.8°C (30.6°F) and -0.7°C (30.7°F), respectively. Maximum recorded temperatures occurred in August (31.3°C [88.3°F]) and July (30.6°C [87.1°F]) (USGS 2020).

Table 7. Mean monthly surface water temperature calculated from USGS data collected at Reedy Island between 2009 and 2019.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly surface water temperature (C)	2.7	2.7	5.5	11.6	18.1	24	27.7	27	23.9	18.5	11.4	6.5

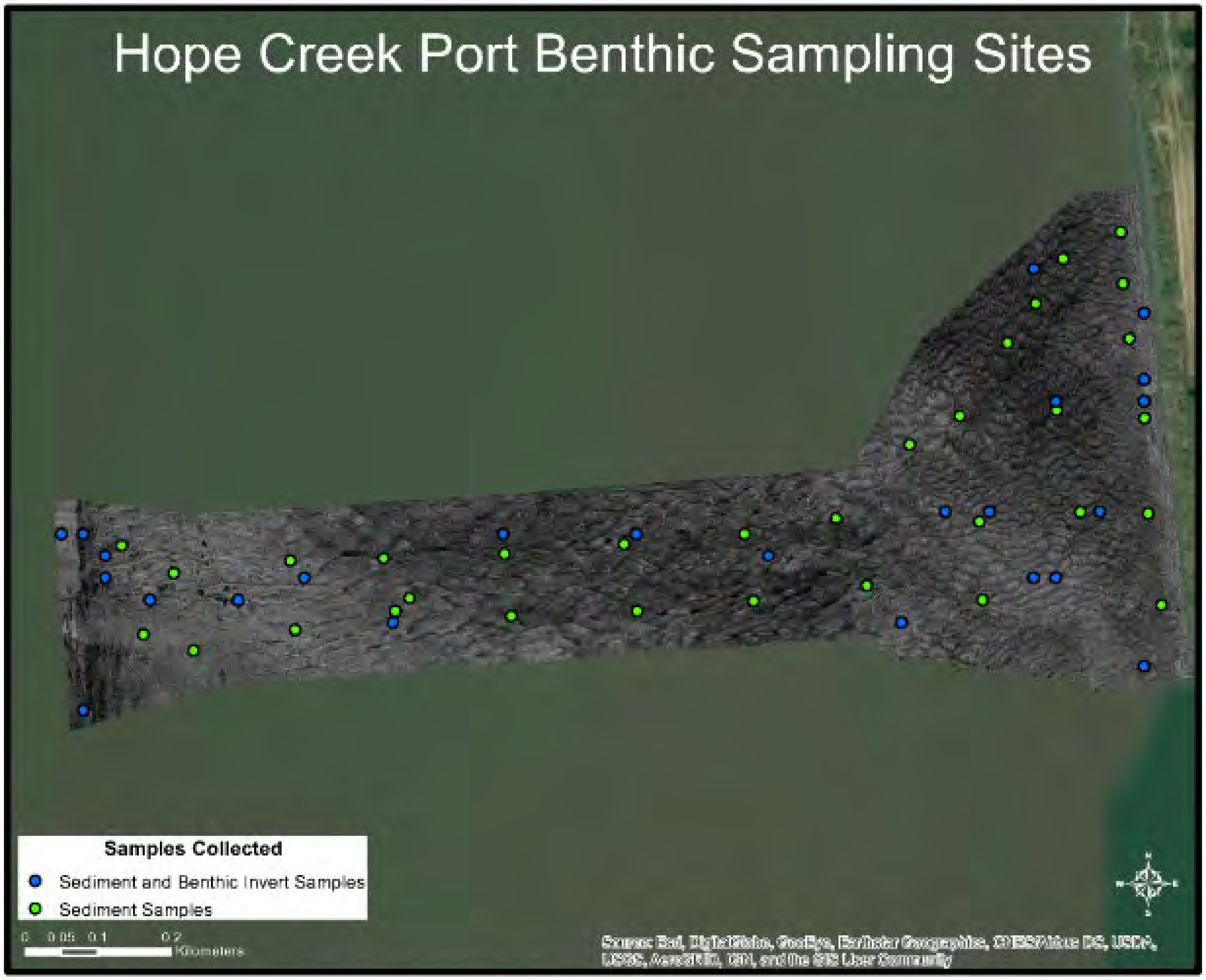
4.1.2.3 Suspended Sediment

The site of the proposed Port lies within the lower estuary and upstream tidal river where the highest concentration of suspended sediments occur (Sutton *et al.* 1996). Water clarity within this area of the River has been classified as fair (i.e., visibility limited to approximately 0.9 m [3 ft] or less) by the United States Environmental Protection Agency (EPA), though water clarity upstream and downstream of this reach were classified as poor (i.e., visibility limited to approximately 0.6 m (2 ft) or less) (USEPA 1998). Ambient suspended sediment concentrations near the Project site from 2009 to 2018 range from an annual average of 26.2 to 42.4 mg/L, representing typical conditions. Maximum suspended sediment concentrations may be substantially higher. The Estuarine Turbidity Maximum in the Delaware River is typically centered between Artificial Island and New Castle, Delaware, (RKM 80 and 100 [RM 50 and 62]) approximately 22.5 km (14 mi) upstream of the proposed Port. Cook et al. (2007) reported ambient maximum concentrations up to 775 mg/L near the bottom of the water column during spring tides at New Castle.

4.1.3 Bottom Substrate

Previous studies indicate that bottom substrate in the river near Artificial Island is composed primarily of fine-grained silts, clays, and fine sand. To obtain site-specific information, PSEG commissioned bathymetric and geophysical surveys of the Project site portion of the action area. The bathymetric survey was conducted with a multibeam echo sounder ("MBES"); a side scan sonar ("SSS") was utilized for the geophysical survey. Both surveys were conducted in August 2020. Additionally, PSEG implemented a benthic sampling program within the dredge footprint. Thirty-two benthic cores were collected for sediment analysis between December 2019 and March 2020; benthic grabs were collected at an additional 24 sites in October 2020 for sediment and benthic invertebrate analysis (Figure 5). Those 24 sites were selected using a stratified-random sampling approach based on water depth (shallow: less than 7.6 m (25 ft), and deep: greater than 7.6 m (25 ft) and substrate province, which was defined by the intensity of the backscatter return (i.e., the grayscale value, 0 – 254), where darker areas indicate a stronger return and lighter areas indicate a weaker return and greater signal absorption by the substrate. Variation among substrate provinces is illustrated in Figure 6 and Figure 7.

Results of the benthic surveys and the benthic sampling program agree with previous surveys near Artificial Island. Backscatter from the MBES and reflectivity from the SSS appear to indicate the presence of a few small patches of hard substrate in the Project area near the Federal Navigation Channel. Benthic substrate throughout the remainder of the Project area is largely composed of sand with silt and clay in smaller proportions (Figure 7). Silt and clay were generally more dominant in deeper waters near the Federal Navigation Channel. Gravel was largely confined to nearshore areas. Of the 24 grabs collected, biological structures were present in only two samples: one grab sample included hard substrate with epifauna present; one grab sample included shell hash. Shellfish were also present in both samples with biological structures. No evidence of vegetated habitat or biogenic habitats was observed in the grab samples.


Hope Creek Port Benthic Sampling Sites
Samples Collected
Sediment and Benthic Invert Samples
Sediment Samples
0 0.05 0.1 0.2
Kilometers

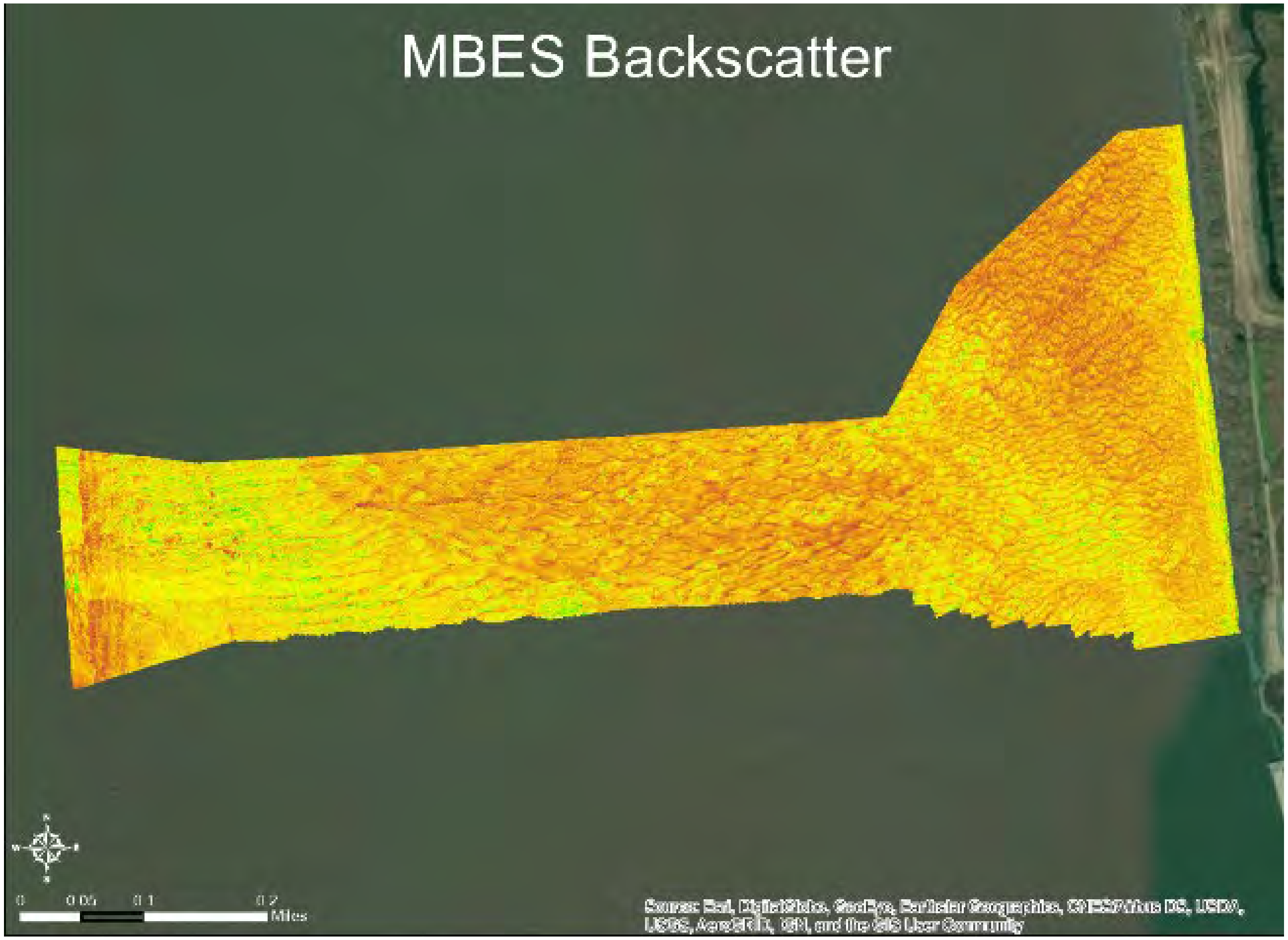
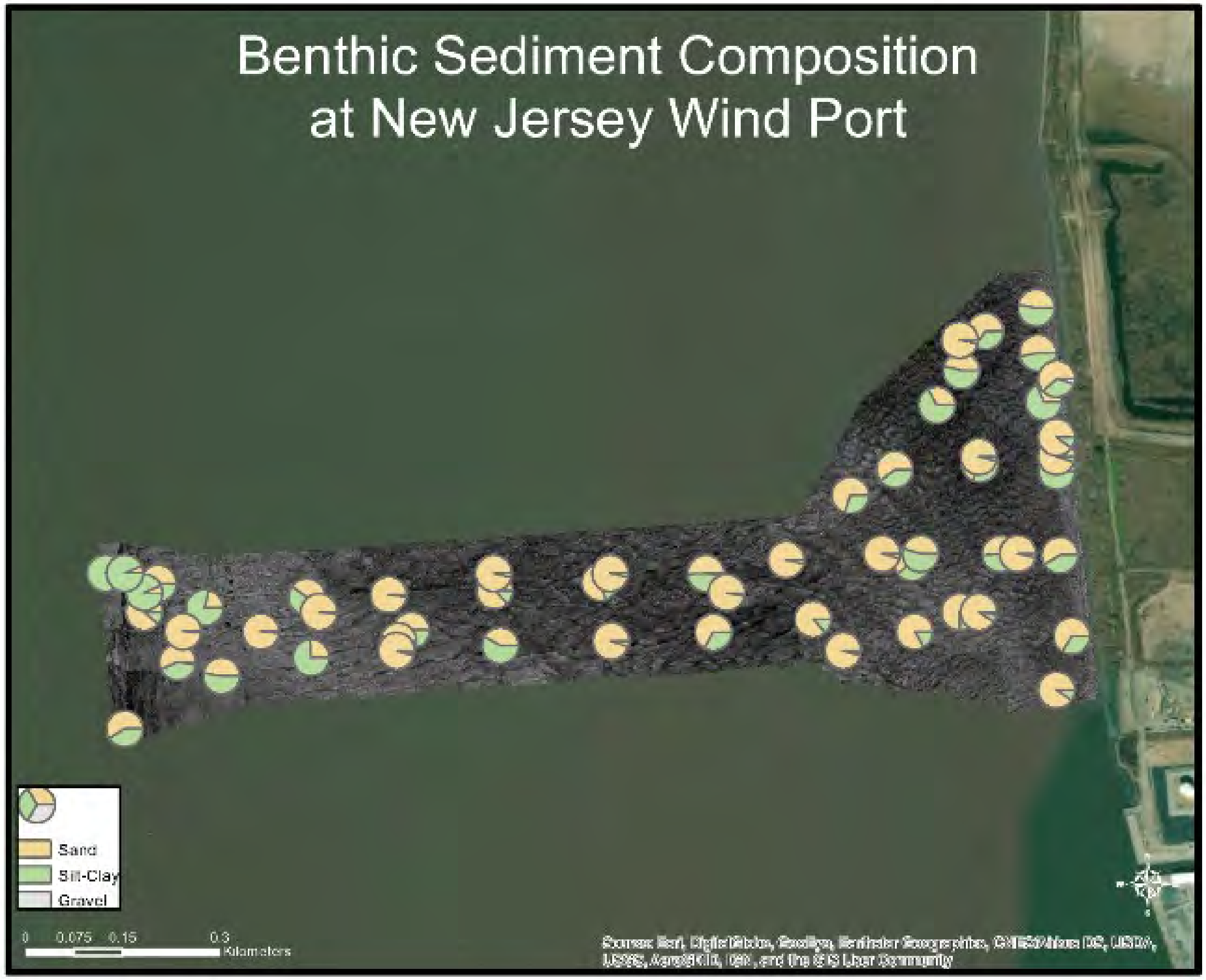


Figure 6. Backscatter data from the multibeam bathymetric survey showing the bottom topography in the Project area (Figure 3 from the BA)


Benthic Sediment Composition
at New Jersey Wind Port
Sand
Silt-Clay
Gravel
0 0.075 0.15 0.3
Kilometers

Sediment analysis of benthic core and grab samples collected within the dredge footprint indicates that the predominant substrate type[3] within the Project area is silty-clayey sand, which comprises approximately 39% of benthic core and grab samples (Table 8). Other substrate types include slightly gravelly sand, slightly gravelly muddy sand, sand, mud, silty sand, and slightly gravelly sandy mud. The majority of sand present in the Project area was fine sand, although medium sand was a substantial component of the substrate; coarse sand was uncommon. Gravel was present in approximately 19% of benthic core samples and 67% of benthic grab samples but made up less than 5% of the sample when present. The median grain size for each sample was estimated based on sediment grain size composition.[4] Excluding benthic core samples containing gravel,[5] the median grain size ranged from 0.02 mm to 0.67 mm. Table 8 shows average median grain size for each substrate type. Grain size analysis of the benthic grab samples showed that the average median grain size decreased as substrate increased in firmness, indicating that the firmer benthic substrates in the dredge footprint comprise tightly packed small grains and the softer substrates are composed of larger grains that are less consolidated. The benthic grab data also showed a higher proportion of silt-clay sediments in deep areas (i.e., depths greater than approximately 7.6 m (25 ft) of the dredge footprint, compared to the shallow areas.

Table 8. Substrate Classification in the Project Area

Substrate Type	Number of Samples	Percentage of Samples	Average Median Grain Size (mm)*
Silty-clayey sand	22	39.3%	0.06
Slightly gravelly sand	11	19.6%	0.28
Slightly gravelly muddy sand	9	16.1%	12.02
Sand	7	12.5%	0.12
Mud	3	5.4%	0.02
Silty sand	2	3.6%	0.10
Slightly gravelly sandy mud	2	3.6%	1.09

*For substrates containing gravel (i.e., slightly gravelly muddy sand and slightly gravelly sandy mud), the average median grain size was skewed by the presence of gravel, despite the small proportion of the sample it composed.

Benthic core samples were also analyzed for contaminants. Laboratory analysis results indicated contaminant levels throughout the study area were below NJDEP residential cleanup standards. Although sediment grab samples were not analyzed for contaminants, no odor, oily sheen, or manmade debris were observed in any of the samples, indicating that the surficial sediment is likely not contaminated.

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[3] Substrate types were classified based on unconsolidated substrate definitions from the Coastal and Marine Ecological Classification Standard ("CMECS").

[4] The estimation of median grain size relied on mineral grain size descriptors provided in the CMECS manual.

[5] Sediment analysis of the benthic core samples did not classify subcategories of gravel (e.g., pebble). The wide grain size range for the gravel category skewed the median grain size calculation for those samples.

The MBES data show that depths within the Project Area range from -1.2 to -16.8 m (-4 to -55 ft) MLLW. The bottom topography throughout the majority of the Project area is characterized by the presence of sand ripples and megaripples (Figure 8). The western edge of the Project area overlaps with the eastern edge of the Federal Navigation Channel and slopes steeply downward from the edge of the channel wall to the floor of the channel (Figure 10).

Sediment core samples allowed for characterization of the sediment profile at sub-bottom depths of up to 5.2 m (17 ft) at some sampling sites. Generally throughout the Project area, the upper sediment layer (0.6 to 0.9 m [2 to 3 ft]) contained sand, often mixed with clay and/or silt. At many sampling sites there were several thin layers below the surface layer composed of various mixes of clay, silt, and/or sand. At depths greater than 1.8 m (6 ft) from the river bottom, sediment was composed of sand/clay mixes.

Figure 8 – Sand ripples visible in SSS image (Figure 5 in the BA)

In River substrates composed of silt, clay, and fine sand, oligochaetes and amphipods dominate the benthic community (Versar 1991, as cited in USNRC 2011). Previous studies near Artificial Island indicated that the benthic community was largely composed of polychaetes, oligochaetes, and isopods (NRC 1984, as cited in USNRC 2011). Benthic invertebrate data from the grab samples are largely consistent with those from previous studies near Artificial Island. Of the 24 grab samples collected, benthic invertebrates were present in 17 samples. Of the seven grab samples that did not have benthic invertebrates, four grabs penetrated the benthic surface by 1 cm (0.4 in.) or less, resulting in small sample volumes. Two of these samples had a relatively high proportion of gravel, which may indicate coarse substrate and may explain the limited grab penetration.

Benthic invertebrates collected in the dredge footprint included amphipods (*Lepidactylus dytiscus* and *Apocorophium lacustre*), barnacles (*Balanus improvisus*), chironomid insect larvae (*Coelotanypus* spp.), isopods (*Chiridotea almyra*, *Cyathura polita*, and *Synidotea laevidorsalis*), mysid shrimp (*Neomysis americana*), nemertean worms (*Carinoma tremaphoros*), oligochaete worms (Tubificidae spp.), and polychaete worms (*Boccardiella ligerica*, *Heteromastus filiformis*, *Marenzelleria viridis*, *Neanthes succinea*, and *Streblospio benedicti*). Polychaete worms were the most prevalent invertebrate in the benthic samples, accounting for over 48% of all invertebrates collected, followed by barnacles, oligochaetes, and isopods (Table 9). Chironomid insect larvae and nemertean worms were only collected at one site. Oligochaetes were also only collected at a single site but were relatively abundant at that site. The average benthic invertebrate density across all sites was 273 organisms per square meter (Table 9).

Benthic invertebrate densities and community composition varied across the dredge footprint (Figure 9). The highest densities were observed in the shallow areas adjacent to the shoreline, and densities generally decreased moving toward the Federal Navigation Channel. Polychaete worms were present throughout the dredge footprint though in greater abundance closer to the shoreline. Isopods were also present throughout the Project area but comprise a larger proportion of the benthic community closer to the Federal Navigation Channel. Mysid shrimp were only observed in deeper waters located approximately mid-approach channel or further offshore, and chironomid insect larvae were only present at one site adjacent to the Federal Navigation Channel. Amphipods were limited to shallow waters shoreward of the approximate midpoint of the approach channel, and nemertean worms only occurred at one site near the shoreline. Barnacles were found at the two sites with shellfish and shell hash or hard substrate with epifauna present, as well as an additional site where there was no hard substrate present (Figure 9). Tubificid worms (oligochaetes) were also found at the site with shellfish and shell hash present.

Table 9. Benthic Invertebrate Data from Grab Samples

Taxon	Sites Present	Composition	Average Density (#/m^2)
Polychaete worms	11	48.2%	132
Barnacles	3	17.1%	47
Oligochaete worms	1	13.4%	37
Isopod crustaceans	9	12.2%	33
Amphipod crustaceans	7	5.5%	15
Nemertean worms	1	1.8%	5
Mysid shrimp	2	1.2%	3
Chironomid insect larvae	1	0.6%	2
ALL TAXA	**17**	**100%**	**273**

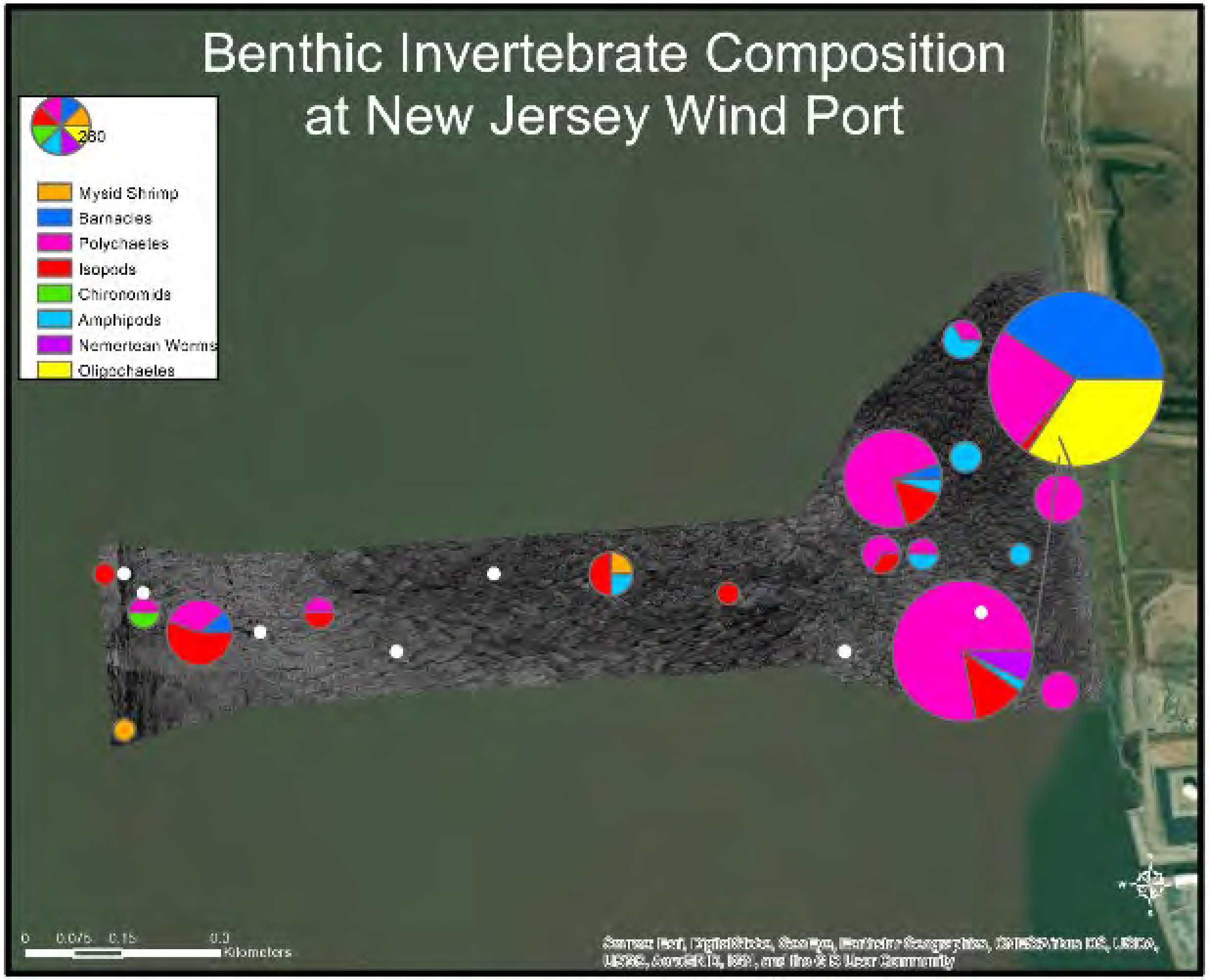

Figure 9 – Benthic invertebrate composition in the dredge footprint at the New Jersey Wind Port. Each pie chart shows the community composition and proportional abundance at each site. The size of each pie represents overall invertebrate density at the site. White circles represent sites with no invertebrates present (Figure 6 from the BA)

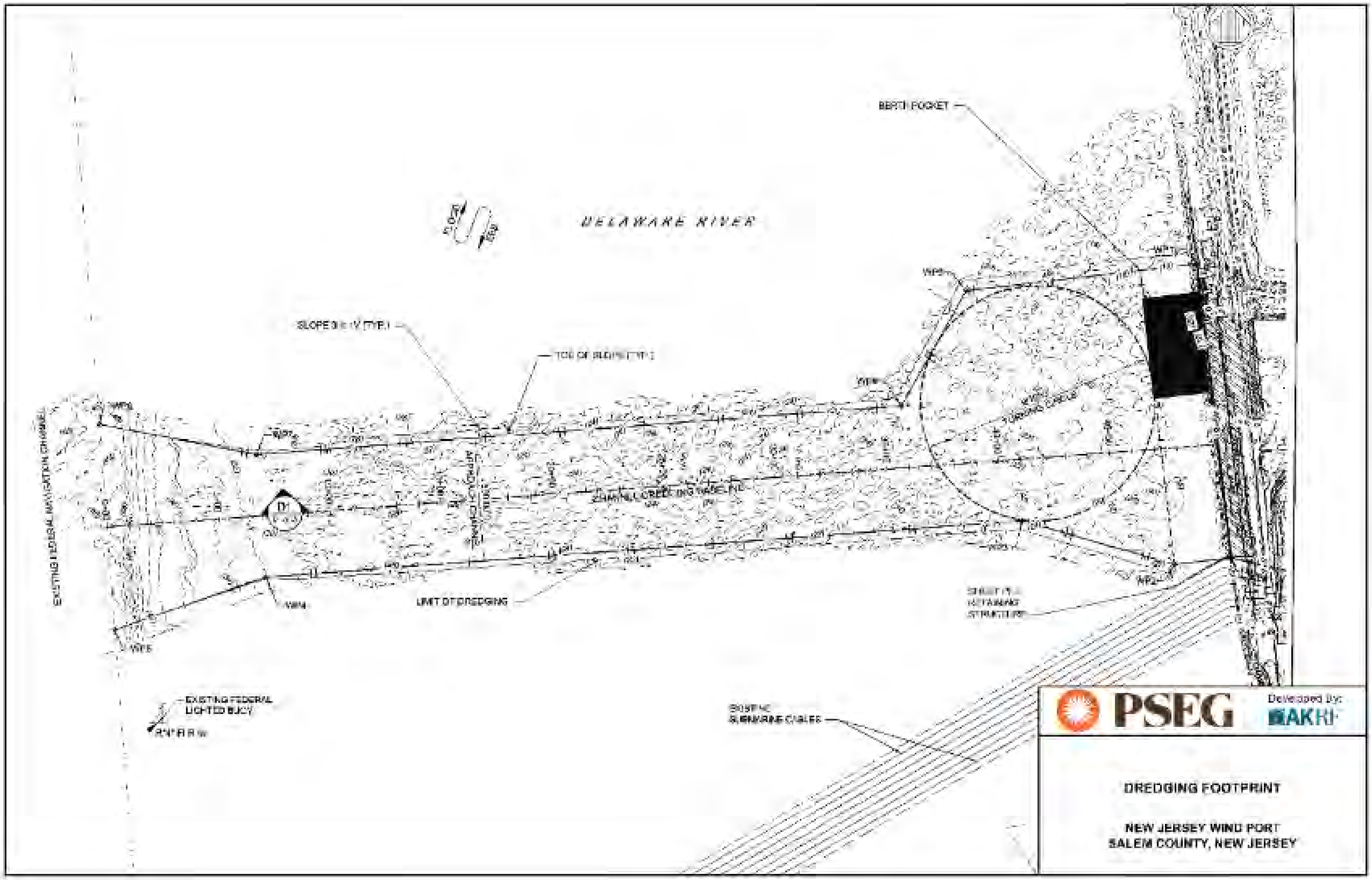

Figure 10 – Dredge design for proposed Port (Source: Moffatt & Nichol dredging plan)

5 STATUS OF THE SPECIES

5.1 Species Not Likely to be Adversely Affected by the Proposed Action

Although 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 ESA-listed species: leatherback, Kemp's ridley, the North Atlantic DPS of green sea turtles, the Northwest Atlantic distinct population segment (DPS) of loggerhead sea turtle, North Atlantic right whales, and fin whales (see Table 10). The rationale for this "not likely to adversely affect" determination is presented below. No take is anticipated or exempted.

Table 10. NLAA Listed Species Present Within the Action Area and their Status.

Listed Species Common Name	Listed Species Scientific Name	Status
North Atlantic DPS 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

5.1.1 Sea Turtles

Sea turtles commonly occur in U.S. Atlantic waters throughout the inner continental shelf from Florida to Cape Cod, MA. Along the Atlantic coast of the United States, leatherback, green and loggerhead sea turtle nesting beaches occur from North Carolina south through Florida. Sea turtle nesting is rare north of North Carolina. There is occasional loggerhead sea turtle nesting in Virginia and a few green and loggerhead sea turtle failed nesting attempts have occurred on Delaware and New Jersey beaches, but there are no established nesting beaches further north.

Beaches in the two states do not support regular nesting of either species. In the United States, some Kemp's ridley turtle nesting has occurred along the coast of Texas, but most Kemp's ridley turtles nest in mass in Tamaulipas, Mexico, where nearly 95% of worldwide Kemp's ridley nesting occurs.

Northward and inshore movement into waters of the Greater Atlantic Region from southern nesting beaches begins in the springtime. Sea turtles arrive into mid-Atlantic waters including Delaware Bay and the Delaware River in May. Juvenile, and occasionally adult sea turtles are expected to opportunistically forage in the Delaware Bay and Delaware River from May through the end of November. In the fall, as water temperatures cool, most sea turtles leave the region's waters by the end of November. Sea turtle presence in mid-Atlantic waters after this time is considered unlikely aside from cold-stunned individuals that fail to migrate south.

The functional ecology of these four sea turtle species is varied. Loggerhead sea turtles are primarily carnivorous feeding mainly on mollusks and crustaceans. Kemp's ridley sea turtles are omnivorous feeding primarily on crabs and crustaceans. Green sea turtles are herbivores feeding mainly on algae and seagrasses, although they may also forage on sponges and invertebrates. Leatherback sea turtles are specialized feeders and prey primarily upon jellyfish.

Additional background on life history and population status can be found in the recovery plans: loggerhead (NMFS and USFWS, 2008), Kemp's ridley (NMFS et al. 2011), green (NMFS and USFWS, 1991), and leatherback (NMFS and USFWS, 1992).

Sea Turtle Presence in the Action Area

Adult and juvenile sea turtles are expected to be present within the action area. Specifically, in the Delaware Bay and the Delaware River below the Chesapeake & Delaware Canal (C&D Canal) at RKM 94.3 (RM 58.6) from May through the end of November, where they may be foraging. The action area is outside the range of sea turtle nesting, therefore, no sea turtle hatchlings are expected to be present within the action area.

5.1.1.1 Consequences of the Proposed Action on Sea Turtles

Leatherback, green, Kemp's ridley, and loggerhead sea turtles may occur in the Delaware River and Delaware Bay and be exposed to the consequences of pile driving, dredging, habitat modification, and vessel traffic associated with the proposed construction and subsequent use of the Port in its support role for offshore wind development. Consequences of the proposed activities include potential entrapment of sea turtles in dredging equipment, underwater noise produced during pile driving, temporary increases in sedimentation and turbidity, loss of benthic resources and foraging habitat due to dredging and construction activities, and vessel traffic (construction and operation-related).

Dredging Entrapment

Hydraulic cutterhead and mechanical clamshell dredges will be used for dredging operations during construction of the proposed Port. Sea turtles may be exposed to dredging activities as they migrate through and forage in the action area.

Cutterhead dredges have a rotating cutter apparatus surrounding the intake of a suction pipe and may be hydraulic and mechanical. The cutterhead dredge operates with the dredge head buried in the sediment; however, a flow field is produced by the suction of the operating dredge head. The amount of suction produced is dependent on linear flow rates inside the pipe and the pipe diameter (USACE https://dots.el.erdc.dren.mil/doer/tools.html). High flow rates and larger pipes create greater suction velocities and wider flow fields. Suction strength decreases exponentially with distance from the dredge head (Boysen and Hoover 2009). Sea turtles are not known to be vulnerable to entrainment in cutterhead dredges, presumably because they are able to avoid the relatively small intake size and low intake velocity. Thus, if a sea turtle were to be present at the dredge site within the action area, it is extremely unlikely that hydraulic cutterhead dredging operations would result in injury or mortality of a turtle.

Mechanical clamshell dredges use buckets to excavate dredge materials. This type of mechanical dredging entails lowering the open bucket or clamshell through the water column, closing the bucket after impact on the bottom, lifting the bucket up through the water column, and emptying the bucket into a barge. The bucket operates without suction or hydraulic intake, moves relatively slowly through the water column and affects only a small portion of the benthic substrate at any time. In order to be captured, a sea turtle must be stationary on the bottom directly below the dredge bucket as it reaches the substrate and closes. Individuals captured in dredge buckets can be injured or killed by the entrapment itself, or buried in sediment during dredging and/or when sediment is deposited into the dredge scow. These animals may suffer stress or injury, which can lead to mortality. Sea turtles are not known to be vulnerable to entrapment in mechanical dredges. Because of their swimming ability, they are able to move away from the dredge bucket as it is lowered slowly through the water column. Thus, if a sea turtle were to be present at the dredge site, it would be extremely unlikely to be injured or killed by a mechanical dredge. Based on this information, an interaction between a sea turtle and the mechanical clamshell dredge is extremely unlikely to occur.

Underwater Noise

For construction of the proposed Port, an impact hammer will be used to drive roughly 1,350 30-inch square concrete piles. Therefore, impacts to sea turtles from elevated levels of underwater noise is possible. The hearing capabilities of sea turtles are poorly known and there is little available information on the effects of noise on sea turtles. Some studies have demonstrated that sea turtles have fairly limited capacity to detect sound, although all results are based on a limited number of individuals and must be interpreted cautiously. McCauley et al. (2000) noted that decibel levels above 175 dB re 1μPaRMS elicited avoidance behavior of sea turtles. McCauley et al. (2000) used impulsive sources of noise (e.g., air gun arrays) to ascertain the underwater noise levels that produce behavioral modifications in sea turtles. As no other studies have been done to assess the effects of impulsive and continuous noise sources on sea turtles, McCauley *et al.* (2000) serves as the best available information on the levels of underwater noise that may produce a startle, avoidance, and/or other behavioral or physiological response in sea turtles. In our analysis, we consider the sound levels that would cause noise-induced threshold shifts (i.e., as increases in the threshold of audibility or the sound has to be louder to be detected) of the ear at a certain frequency or range of frequencies. Based on the best available information (see references in the acoustic tool referred to below), a temporary threshold shift (TTS) occur if a sea turtles is exposed to underwater noise greater than 226 dB re 1 μPa Peak SPL or 189 dB re 1 μPa2s SEL. Based on McCauley *et al.* (2000), we expect that sea turtles will experience behavioral modifications at 175 dB re 1 μPa RMS. A permanent threshold shift would require exposure to higher sound levels.

We used the acoustic tool developed by us to calculate the estimated distance of sound from the source[6]. We use a 30-inch steel pipe with a cushion impact hammer as a proxy for the 30-inch concrete piles to calculate the distance of sound causing behavioral modifications (Table 11). Based on the calculations, the peak (i.e., approximately 10 m from the source) sound pressure level (SPL_{peak}) associated with impact pile driving to install concrete piles is 194 dB re 1 μPa. The estimated root mean square sound pressure level (SPL_{RMS}) at the same distance is 189 dB re

[6] Available at https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-consultation-technical-guidance-greater-atlantic

1 μPa (Table 11). Based on this, we expect that turtles within 38 meters from the piles (and thereby from the shore) will react to the sound by avoiding the area. We do not expect exposure to noise from driving the 24-inch sheet piles or the 19 inch H piles for the submerged protective wall (based on using a 20-inch steel pile as a proxy).

Peak dB for a 30-inch diameter steel pile driven with a cushioned impact hammer in five-meter deep water was measured to 195 dB at a distance of ten meters. SEL and RMS were measured to 169 dB re 1 μPa and 189 dB re 1 μPa, respectively (Table 11).

Table 11. Proxy-Based Estimates for Underwater Noise.

Type of Pile	Hammer Type	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})
30" Steel Pipe	Cushioned Impact	194	189	169
24" AZ Steel Sheet	Vibratory	175	160	160
20" Steel Pipe	Vibratory	194	161	169

Table 12. Estimated Distances to Sea Turtle Injury and Behavioral Thresholds.

Type Pile	Hammer Type	Distance (m) to Sea Turtle TTS (SEL weighted) 189 dB_{RMS}	Distance (m) to Sea Turtle TTS (Peak SPL) 226 dB_{Peak}	Distance (m) to Sea Turtle PTS (SEL weighted) 204 dB_{SEL}	Distance (m) to Sea Turtle PTS (Peak SPL) 232 dB_{Peak}	Distance (m) to Sea Turtle Behavioral Threshold 175 dB_{RMS}
30" Steel Pipe	Cushioned Impact	NA	NA	NA	NA	38.0
24" AZ Steel Sheet	Vibratory	NA	NA	NA	NA	NA
20" Steel Pile	Vibratory	NA	NA	NA	NA	NA

Pile driving associated with the proposed Port will exceed the threshold for behavioral effects (i.e., 175 dB re 1 μPa) for sea turtles within 38 m of pile driving (Table 12). It is expected that underwater noise levels will be below 175 dB RMS at distances beyond 38 m from the location where pile driving occurs. Should sea turtles move into the action area where their acoustic behavioral threshold extends, as described above, it is reasonable to assume that upon detecting underwater noise levels of 175 dB RMS, they will modify their behavior such that they redirect their course of movement away from the ensonified area and away from the pile driving. If any movements away from the ensonified area do occur, it is extremely unlikely that these movements will affect essential sea turtle behaviors (*e.g.*, resting, migration, nesting), and the width of the Delaware River in the action area is sufficiently large enough to allow sea turtles to avoid the ensonified area while continuing to forage and migrate. Given the small distance a sea turtle would need to move to avoid the disturbance levels of noise, any effects are too small be able to be meaningfully measured or detected. Therefore, the effects of noise on sea turtles are insignificant.

Sedimentation and Turbidity

Dredging operations for the proposed Port will result in increased sedimentation and turbidity in the water column. The resulting sediment plume is typically present from the dredge site and decreases in concentration as sediment falls out of the water column further from dredging operations. The nature, degree, and extent of sediment suspension around a dredging operation is 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).

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 indicate that total suspended sediment (TSS) concentrations above background levels may be present throughout the bottom six feet (1.8 meters) of the water column for a distance of approximately 305 m (1,000 ft) (USACE 1983). Elevated suspended sediment levels are expected to be present within a 984.3 to 1,640.4 ft (300-500 m) radius of the cutterhead dredge (Hayes *et al.* 2000, LaSalle 1990, USACE 1983, Wilber and Clarke 2001). TSS concentrations associated with cutterhead dredge sediment plumes typically range from 11.5 to 282.0 mg/L with the highest levels (550.0 mg/L) detected adjacent to the dredge head and concentrations decreasing with greater distance from the dredge(Nightingale and Simenstad 2001, USACE 2015).

Mechanical clamshell bucket dredging operations have been shown to produce TSS in the range of 105 mg/L in the middle of the water column to 445 mg/L near the bottom (210 mg/L, depth-averaged) (USACE 2001). Furthermore, a study by Burton (1993) measured TSS concentrations at distances of 500, 1,000, 2,000, and 3,300 ft (152, 305, 610, and 1006 m) from dredge sites in the Delaware River and were able to detect concentrations between 15 mg/L and 191 mg/L up to 2,000 ft (610 m) from the dredge site. The U.S. Army Corps of Engineers conducted extensive monitoring of mechanical dredge plumes in New York and New Jersey and found that independent of bucket type or size, plumes dissipated to background levels within 600 ft (183 m) of the source in the upper water column and 2,400 ft (732 m) in the lower water column (USACE 2015). Based on these studies, elevated suspended sediment concentrations at several hundreds of mg/L above background may be present in the immediate vicinity of the bucket, but would settle rapidly within a 2,400- ft (732 m) radius of the dredge location.

The installation of piles for the proposed Port will also disturb bottom sediments and may cause a temporary increase in sedimentation and turbidity in the water column. We expect pile driving activities to produce total suspended sediment (TSS) concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 300 feet (91 meters) of the pile being driven (FHWA 2012). The TSS levels expected for pile driving or removal are below those shown to have adverse effect on benthic communities (390.0 mg/L (EPA 1986)). TSS is most likely to affect sea turtles if a plume causes a barrier to normal behaviors or if elevated levels of suspended sediment affect prey. Sea turtles may be exposed to effects of TSS or increased sediment through the uptake of water when they feed. Even if sea turtles ingested the transient plumes, it would be brief and the increase in TSS of 5 to 10 mg/L is not likely to increase the risk of harm to sea turtles. As sea turtles breathe air and are highly mobile, they are likely to be able to avoid the sediment plume and any consequences to their movement is likely to be insignificant. While the increase in suspended sediments may cause sea turtles to alter their normal movements, any change in behavior is not able to be measured or detected, as it will only involve minor movements that alter their course out of the way of the sediment plume, which will not disrupt any essential life behaviors. Furthermore, the area that will be temporarily impacted by increased sedimentation (up to 732 m) is small compared to the available foraging habitat within the action area. Based on this information, and given that increased sedimentation in the water column is expected to be minimal and temporary and settle out of the water column quickly in the rapidly flowing Delaware River, effects of increased sedimentation and turbidity on sea turtles and their prey from dredging are too small to be meaningfully measured or detected.

Habitat Modification

Dredging, pile driving, and mitigation associated with construction of the proposed Port will directly disturb the river benthos and alter the substrate, potentially reducing availability of prey species or altering prey composition for sea turtles. Benthic substrate in the action area is largely composed of sand with smaller proportions of silt/clay and no SAV was observed during surveys of the proposed project site. There is likely to be some entrainment of mobile sea turtle prey items as well as benthic invertebrates that do not have sufficient (or any) mobility to avoid the dredge. However, the soft substrate located within the action area experiences daily disturbance (sedimentation from propellers/prop wash from vessel traffic in the Delaware River) and we expect that this has some impact on the ability of these areas to support an abundant and diverse community of benthic invertebrates. This may mean that sea turtles are more likely to forage in areas of the Delaware Bay and the Delaware River estuary outside of the action area. The action area is a small fraction of the bay and estuary. Thus, impacts to prey will have an insignificant effect on the availability of prey for sea turtles.

In the dredging areas where sea turtles are expected to be present 1,960,000 CY of sand/silt will be dredged for construction of the proposed Port and 500,000 CY during subsequent maintenance dredging events. The mitigation plan proposes to create "sand-wave habitat" within 120 acres of soft bottom habitat in the Delaware River to serve as a compensatory mitigation site. The area to be affected by dredging activities, the mitigation site, and pile driving is small compared to the available foraging habitat within the action area. While there is likely to be some reduction in the amount of prey, these losses are limited in space and time. That is, these reductions will only be experienced in the areas being dredged and will only last as long as it takes benthic resources to return to the action area. We do not expect that these reductions in forage will have impacts on the fitness of any sea turtles. The river is approximately four kilometer (km) wide and behavioral modification from exposure to pile driving noise is expected to only occur within 23 meters from the pile. Since installation of piles will only occur at the port site (i.e. close to the shore), noise from pile driving will not alter the habitat in any way that prevents sea turtles from moving to other near-by areas that may be more suitable for foraging. Further, because of the low salinity upstream of the Port site, the Port site is located at the upstream end of sea turtle presence in the Delaware Estuary. Thus, the area does not function as a migratory pathway. We expect that the concrete structures will function as artificial reefs that will provide habitat for invertebrates commonly preyed upon by Kemp's ridley and loggerhead sea turtles (e.g., mollusks, crabs, etc.). Thus, the structures will not reduce and may increase forage available to these two species of sea turtles. The structures will not reduce the availability of SAV that adult green sea turtles graze upon since we expect that the structures will be placed in areas that are free of SAV to avoid further impacts to EFH. Given the small portion that will be affected of the total habitat available for foraging sea turtles, any consequences to foraging from periodic dredging of the channels, pile driving, and mitigation are too small to be meaningfully measured or detected, and are insignificant.

Vessel Traffic

Vessel strikes remain a relatively rare cause of mortality to sea turtles and an increase in vessel traffic in the action area would not necessarily translate into an increase in vessel strikes. However, although rare, interactions with project vessels and subsequent vessel traffic related to the proposed Port operation could potentially injure or kill sea turtles. Interactions between vessels and sea turtles are not well 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 because they may be able 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). In addition to recreational vessels, there have been an annual average of 33,556 vessel trips by self-propelled vessels from Philadelphia to the Atlantic Ocean over the period from 2010 to 2019 (USACE, Waterborne Commerce Data). However, 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 without being harmed (NMFS 2013b). Based on the best available information, the likelihood of an interaction between a sea turtle and one of the large cargo vessels transiting to or from the proposed port is extremely unlikely to occur.

There will also be an increase in vessel traffic in the Delaware River due to construction activities. The increase or change in vessel traffic associated with construction for the proposed project is small. Dredging operations typically add approximately six vessels to the action area. Dredging operations, similarly, exclude other vessels unrelated to the project from the action area while dredging is underway. The addition of these project-related vessels will be intermittent, temporary (three to four times annually), and restricted to a small portion of the overall size of the action area. The potential for adding a minimal number of project vessels to the existing baseline (as discussed above) may increase vessel strike risk to sea turtles. However, we expect that due to the temporary and localized operation of the vessels associated with construction activities and that some of the construction activities are scheduled outside of turtle presence in the action area, any increase in the risk of vessel strike from project vessels is will be too small to be meaningfully measured, detected, or evaluated. Therefore, we have determined that effects from vessel activities are insignificant.

5.1.2 Whales

North Atlantic right whales are large baleen whales. Their primary food sources are zooplankton, including copepods, euphausiids, and cyprids. Right whales commonly feed at or just below the water's surface and at depth. They primarily occur in coastal or shelf waters, although movements over deep waters are known to occur. Right whales migrate to higher latitudes during spring and summer (NMFS 2005). 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. Whales begin moving north along the coast in the vicinity of Delaware Bay during November to April while on their way to northern foraging areas. Right whales are commonly found foraging from January to October and overwintering from November to January in waters in and around Massachusetts Bay and north along the east coast into Canadian 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. During the summer, fin whales feed on krill, small schooling fish (e.g., herring, capelin, and sand lance), and squid, but fast in the winter while they migrate south to warmer waters. They occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally. In the mid-Atlantic, foraging occurs year round in the mid-shelf area off the east end of Long Island. Fin whales use the nearshore coastal waters of the Atlantic Ocean as they migrate to and from calving and foraging grounds. There is evidence of wintering areas in mid-shelf areas east of New Jersey. Fin whale calving may take place offshore in mid-Atlantic waters from October to January. Fin whales may occupy both deep and shallow waters in and around Delaware Bay and are most abundant in spring, summer, and fall, but may have some presence during the winter months. Therefore, fin whales could be present year-round.

Whale Presence in 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. No right whales have been observed inland of the COLREGS Demarcation Line at Delaware Bay since 2002 (NMFS 2017d). Right whales are most likely to occur in waters off the New Jersey coast between November and April as they migrate between northern foraging and southern calving grounds, but could be present year round (NMFS 2017d). Adult and juvenile fin whales could theoretically be present year round within the action area in Delaware Bay or at its mouth but they have never been observed in these waters. Given the lower salinity and shallower depths throughout most of the action area compared to offshore marine waters, right and fin whales are not present in the lower Delaware

River. However, although unlikely, it is possible that migrating adult and juvenile whales may be seasonally present within the Delaware Bay.

5.1.2.1 Consequences of the Proposed Action on Whales

ESA listed species of whales will not occur in the shallow, mesohaline areas in the Delaware River where pile driving, dredging, and habitat modification will occur and, thus, will not be exposed to any consequences of pile driving, dredging, or habitat modification. Although rare and unlikely, fin and North Atlantic right whales may be present where increased vessel traffic will occur at and offshore of the mouth of the Delaware Bay. As such, this section will only address the effects of vessel traffic to whales.

Vessel Traffic

We anticipate that the proposed NJWP will receive up to 160 vessel calls annually. These vessels will travel to and from the port through the mouth of the Delaware Bay. Collision with vessels remains a source of anthropogenic mortality for whales and 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, 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 vessel traffic caused by the proposed project would increase the risk of vessel strikes to listed species.

Fin and right whales occur throughout the continental shelf and slopes of the mid-Atlantic (NMFS 2017c). Sightings and satellite tracking data along the east coast indicate that endangered large whales such as right and fin whales rarely venture into bays, harbors, or inlets (Southall and Scholik-Schlomer 2007). However, right whale sightings have been documented near the mouth of the Delaware Bay and in a few rare occasions within the bay. For instance, three right whale observations were reported at the mouth of the Delaware Bay during the two years of 2020 and 2021 (https://whalemap.org/WhaleMap/). 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 near the NJWP site or in the lower Delaware River.

Vessels transporting materials for construction or supporting dredging and pile driving activities will travel within the Delaware River and not occur in the Delaware Bay or travel through its mouth. Thus, whales will not be exposed to these vessels. However, the transit of delivery and installation vessels could expose any fin whales and right whales within the pilot area and precautionary area (just outside and inside of the Delaware Bay mouth, respectively) to vessel strike.

Injuries and mortalities from vessel strikes are a threat to North Atlantic right and fin whales. Reports from 2009 to 2018 indicate that right whales experienced four vessel strike mortalities and five serious injuries, two of which were prorated serious injuries, in the U.S. or in an unknown country of origin. The annual average of vessel strikes between 2012 and 2016 in U.S.

waters was 1.4 for fin whales (Hayes *et al.* 2019). Large whales, particularly right whales, are vulnerable to injury and mortality from ship strikes. Ship strike injuries to whales occur in two ways: (1) propeller wounds characterized by external gashes or severed tail stocks; and (2) blunt trauma injuries indicated by fractured skulls, jaws, and vertebrae, as well as massive bruises that sometimes lack external expression (Laist et al. 2001). Collisions with smaller vessels may result in propeller wounds or no apparent injury, depending on the severity of the incident. Laist *et al.* (2001) reports that of 41 ship strike accounts that reported vessel speed, no lethal or severe injuries occurred at speeds below ten knots, and no collisions have been reported for vessels traveling less than six knots. An analysis by Vanderlaan and Taggart (2007) showed that at speeds greater than 15 knots, the probability of a ship strike resulting in death of a whale increases asymptotically to 100%. At speeds below 11.8 knots, the probability of a vessel decreases to less than 50%, and at 10 knots or less, the probability is further reduced to approximately 30%. Most ship strikes have occurred at vessel speeds of 13-15 knots or greater (Jensen and Silber 2003, Laist *et al.* 2001). Therefore, vessel strikes that injure or kill whales are most likely occur when vessels travel at speeds of 10 knots or more (Laist *et al.* 2001, Pace and Silber 2005, Vanderlaan and Taggart 2007).

A Seasonal Management Area (SMA) was established 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 Bay and is active from November 1 through April 30 of any given year. Vessels 65 ft or longer are required to operate at speeds of 10 knots or less when traveling through the SMA. Vessels for future NJWP operations are expected to range in size from approximately 145 m (475 ft) to 180 m (590 ft) in length and tug vessels are expected to be up to approximately 32 m (105 ft) in length. Therefore, the vessels traveling to and from the NJWP must adhere to the speed requirements of 10 knots or less, thereby reducing vessel traffic impacts to whales. In addition, federal regulations, as specified in 50 CFR 222.32, require 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 vessels associated with the NJWP. Therefore, the speed of the vessels will not exceed 10 knots while transiting to/from the Atlantic Ocean from November 1 through April 30, thereby reducing the likelihood of vessel collision impacts during that time. Collisions with an installation or delivery vessel could occur, but the speed (up to 10 knots) during transit lessens the probability of a ship strike resulting in lethal or serious injuries. Requirements to steer a course away from a right whale may further reduce the risk of vessel-whale collisions. Once the vessels have entered the Delaware Bay, installation and delivery vessels would travel at speeds of 10 to 20 knots in the Federal Navigation Channel. The risk of serious injury or death increases if the vessels travel at speeds above 10 knots. However, though there are no physical barrier preventing whales from entering the Delaware Bay, the probability of a whale being present within the Delaware Bay is extremely low.

Based on the rarity of whales within the action area, that vessels will travel as a 10 knot speed or lower between November 1 and April 30, and that vessels are required to keep a 500-yard distance from an observed whale, we find it extremely unlikely that a whale will be exposed to a vessel strike. Therefore, effects from vessel traffic caused by the proposed action is extremely unlikely to occur.

5.2 Species Likely to be Adversely Affected by the Proposed Action

5.2.1 Shortnose Sturgeon

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

5.2.1.1 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. We provide general life history attributes in Table 13 below.

Table 13. General Life History for the Shortnose Sturgeon (Range-Wide)

Stage	Size (mm)	Duration	Behaviors/Habitat Used
Egg	3-4	13 days post spawn	stationary on bottom; Cobble and rock, fresh, fast flowing water
Yolk Sac Larvae	7-15	8-12 days post hatch	Photonegative; swim up and drift behavior; form aggregations with other YSL; Cobble and rock, stay at bottom near spawning site
Post Yolk Sac Larvae	15 – 57	12-40 days post hatch	Free swimming; feeding; Silt bottom, deep channel; fresh water
Young of Year	57 – 140 (north); 57-300 (south)	From 40 days post-hatch to one year	Deep, muddy areas upstream of the saltwedge
Juvenile	140 to 450-550 (north); 300 to 450-550 (south)	1 year to maturation	Increasing salinity tolerance with age; same habitat patterns as adults
Adult	450-1100 average; (max recorded1400)	Post-maturation	Freshwater to estuary with some individuals making nearshore coastal migrations

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

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

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

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

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

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

Listing History

Shortnose sturgeon were listed as endangered in 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Shortnose sturgeon are thought to have been abundant in nearly every large East Coast river prior to the1880s (Kynard *et al.* 2016). 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.

5.2.1.2 Current Status

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

Population Structure

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

Recent developments in genetic research as well as differences in life history support the grouping of shortnose sturgeon into five genetically distinct groups, all of which have unique geographic adaptations (see (Grunwald *et al.* 2008, King *et al.* 2001, SSSRT 2010, Waldman *et al.* 2002, Wirgin *et al.* 2005). These groups are: 1) Gulf of Maine; 2) Connecticut and Housatonic Rivers; 3) Hudson River; 4) Delaware River and Chesapeake Bay; and 5) Southeast. The Gulf of Maine, Delaware/Chesapeake Bay and Southeast groups function as metapopulations[7]. The other two groups (Connecticut/Housatonic and the Hudson River) function as independent populations.

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[7] 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.

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

Summary of Status of Northeast Rivers

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

Gulf of Maine Metapopulation

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

Since the removal of the Veazie and Great Works Dams (2013 and 2012, respectively), in the Penobscot River, shortnose sturgeon range from the Bay to the Milford Dam. Shortnose sturgeon now have access to their full historical range. Adult and large juvenile sturgeon have been documented to use the river. While potential spawning sites have been identified, no spawning has been documented. Foraging and overwintering are known to occur in the river. Nearly all pre-spawn females and males have been documented to return to the Kennebec or Androscoggin Rivers. Estimated seasonal adult abundance ranging from 636-1285 (weighted mean), with a low estimate of 602 (95%CI: 409.6-910.8) and a high of 1306 (95% CI: 795.6-2176.4) (Fernandes 2008; Fernandes *et al.* 2010; Dionne 2010 in Maine DMR 2010).

Kennebec/Androscoggin/Sheepscot

The estimated size of the adult population (>50cm TL) in this system, based on a tagging and recapture study conducted between 1977-1981, was 7,200 (95% CI = 5,000 - 10,800; Squiers *et al.* 1982). A population study conducted 1998-2000 estimated population size at 9,488 (95% CI = 6,942 -13,358; Squiers 2003)(Squiers 2003) suggesting that the population exhibited significant growth between the late 1970s and late 1990s. Spawning is known to occur in the Androscoggin and Kennebec Rivers. In both rivers, there are hydroelectric facilities located at the base of natural falls thought to be the natural upstream limit of the species. The Sheepscot River is used for foraging during the summer months. Altenritter *et al.* (2017) found that a large proportion of female shortnose sturgeon tagged in the Penobscot River migrated to the Kennebec River during probable spawning windows. They also found that shortnose sturgeon in the

Penobscot River were larger and had a higher condition factor than shortnose sturgeon in the Kennebec River. Based on this, they speculated that "increased abundance and resource limitation in the Kennebec River may be constraining growth and promoting migration to the Penobscot River by individuals with sufficient initial size and condition." These individuals then return to spawn in the Kennebeck River at larger size that could potentially result in increased reproductive potential compared to nonmigratory females. Thus, migrants could experience an adaptive reproductive advantage relative to nonmigratory individuals. Further, Altenritter *et al.* (2017) noted that although migrants to the Penobscot River may be a small proportion of the Kennebec River population, they could disproportionately contribute to regional recruitment and facilitate population resilience to disturbance.

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.

Connecticut River Population

The Holyoke Dam divides the Connecticut River shortnose population; there is currently limited successful passage downstream of the Dam. No shortnose sturgeon have passed upstream of the dam since 1999 and passage between 1975-1999 was an average of four fish per year. The number of sturgeon passing downstream of the Dam is unknown. Despite this separation, the populations are not genetically distinct (Kynard 1997, Kynard *et al.* 2016, Wirgin *et al.* 2005). The most recent estimate of the number of shortnose sturgeon upstream of the dam, based on captures and tagging from 1990-2005 is approximately 328 adults (CI = 188–1,264 adults; B. Kynard, USGS, unpubl. Data in SSSRT 2010); this compares to a previous Peterson mark-recapture estimate of 370–714 adults (Taubert 1980). Using four mark-recapture methodologies, the long-term population estimate (1989-2002) for the lower Connecticut River ranges from 1,042-1,580 (Savoy 2004). Comparing 1989-1994 to 1996-2002, the population exhibits growth on the order of 65-138 percent. The population in the Connecticut River is thought to be stable, but at a small size.

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

Hudson River Population

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

Delaware River-Chesapeake Bay Metapopulation

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

In Chesapeake Bay, shortnose sturgeon have most often been found in Maryland waters of the mainstem bay and tidal tributaries such as the Susquehanna, Potomac, and Rappahannock Rivers (Kynard *et al.* 2016, SSSRT 2010). Spells (1998), Skjeveland *et al.* (2000), and Welsh *et al.* (2002) all reported one capture each of adult shortnose sturgeon in the Rappahannock River. Recent documented use of Virginia waters of Chesapeake Bay is currently limited to two individual shortnose sturgeon: one captured in 2016 (Balazik 2017) and a second sturgeon (a confirmed gravid female) caught in 2018 in the James River (Balazik, pers. comm. 2018).

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

Southeast Metapopulation

There is no evidence of shortnose sturgeon between the mouth of Chesapeake Bay and the Carolinas. Shortnose sturgeon are only thought to occur in the Cape Fear River and Yadkin-Pee Dee River in North Carolina and are likely 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 likely results 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. Shortnose sturgeon are extremely rare or possibly extirpated from the St. Johns River in Florida as only a single specimen was found by the Florida Fish and Wildlife Conservation Commission during extensive sampling of the river in 2002/2003. In these river systems, shortnose sturgeon occur in nearshore marine, estuarine, and riverine habitat.

Threats

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

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

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

All shortnose sturgeon populations are highly sensitive to increases in juvenile mortality that would result in chronic reductions in the number of sub-adults as this leads to reductions in the number of adult spawners (Gross *et al.* 2002, Secor *et al.* 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 (National Marine Fisheries Service) 1998) and the Shortnose Sturgeon Status Review Team's Biological Assessment of shortnose sturgeon (2010) identify habitat degradation or loss and direct mortality as principal threats to the species' survival. Natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon and include: poaching, bycatch in riverine fisheries, habitat alteration resulting from the presence of dams, in-water and shoreline construction, including dredging; degraded water quality which can impact habitat suitability and result in physiological effects to individuals including impacts on reproductive success; direct mortality resulting from dredging as well as impingement and entrainment at water intakes;and, loss of historical range due to the presence of dams. Shortnose sturgeon are also occasionally killed as a result of research activities. The total number of sturgeon affected by these various threats is not known. Climate change, particularly shifts in seasonal temperature regimes and changes in the location of the salt wedge, may impact shortnose sturgeon in the future (more information on Climate Change is presented in Section 7.0). More information on threats experienced in the action area is presented in the Environmental Baseline section of this Opinion.

Survival and Recovery

The 1998 Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely; the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks: (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. In many rivers, particularly in the Southeast, habitat is compromised and continues to impact the ability of sturgeon populations to recover. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. The loss of any population or metapopulation would result in the loss of biodiversity and would create (or widen) a gap in the species' range.

Summary of Status

Shortnose sturgeon remain listed as endangered throughout their range, with populations in the Northeast being larger and generally more stable than populations in the Southeast. All populations are affected by mortality incidental to other activities, including dredging, power plant intakes and shad fisheries where those still occur, and impacts to habitat and water quality that affect the ability of sturgeon to use habitats and impacts to 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.

5.2.2 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 11). 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.

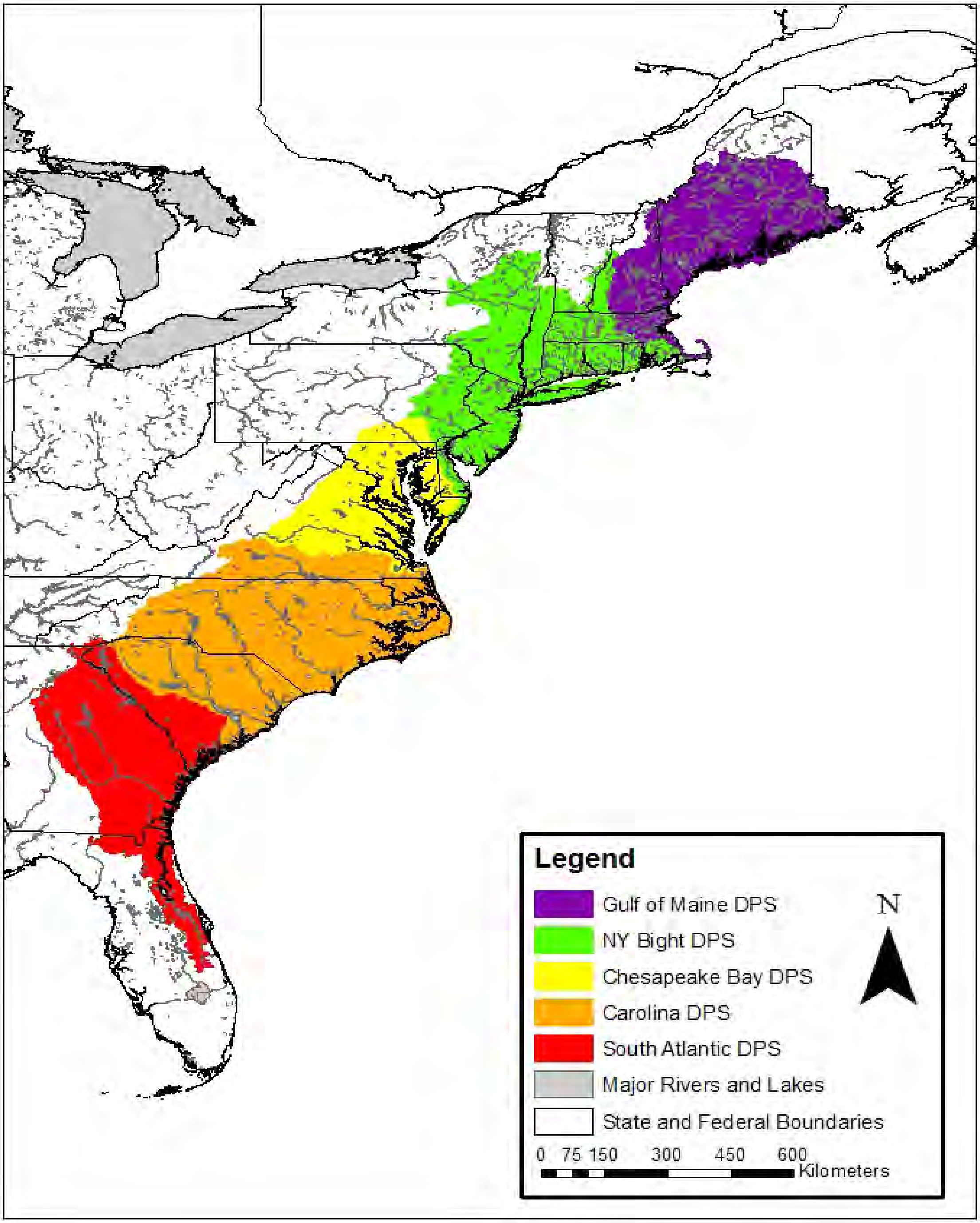

Figure 11. Map depicting the five Atlantic sturgeon DPSs.

5.2.2.1 Life History and General Habitat Use

The Atlantic sturgeon is a long-lived (approximately 60 years), late maturing, estuarine dependent, anadromous[8] fish (ASSRT 2007). They are a relatively large fish, even amongst sturgeon species (Pikitch *et al.* 2005). They grow slowly, eventually reaching 1.5 to 1.8 meter (5 to 6 feet) in length at maturity. 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. 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 14 below.

Table 14. 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

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

Spawning

Atlantic sturgeon spawn in freshwater habitats (ASSRT 2007, NMFS 2017a) at sites with flowing water and hard bottom substrate (Bain *et al.* 2000, Balazik *et al.* 2012c, Gilbert 1989, Greene *et al.* 2009, Hatin *et al.* 2002, Mohler 2003, Smith and Clugston 1997, Vladykov and Greeley 1963). Water depths of spawning sites are highly variable, but may be up to 27 meters (Bain *et al.* 2000, Crance 1987, Leland 1968, Scott and Crossman 1973). Based on tagging records, Atlantic sturgeon return to their natal rivers to spawn (ASSRT 2007), with spawning intervals ranging from one to five years in males (Caron *et al.* 2002, Collins *et al.* 2000, Smith 1985) and two to five years for females (Stevenson and Secor 1999, Van Eenennaam *et al.* 1996, Vladykov and Greeley 1963). Males spawn more frequently than females, and females can spawn in consecutive years, but female spawning periodicity is more variable than males (Breece *et al.* 2021). 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.

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).

Eggs and Larvae

Sturgeon females deposit their eggs on the hard bottom substrate at the spawning site where they become adhesive shortly after fertilization (Hilton *et al.* 2016, Mohler 2003, Murawski and Pacheco 1977). The eggs 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 (post yolk sac) larvae after about eight days (Kynard and Horgan 2002). Post yolk sac larvae drift downstream where they eventually settle, become demersal, and start foraging in freshwater reaches above the salt front (Kynard and Horgan 2002).

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 (Hilton *et al.* 2016) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.* 2000, Hilton *et al.* 2016). 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 1983a, Hilton *et al.* 2016). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other benthic invertebrates (ASSRT 2007, Bigelow and Schroeder 1953a, Bjorndal *et al.* 1994, Guilbard *et al.* 2007).

Subadults and Adults

Upon reaching the subadult phase, individuals enter the marine environment, mixing with adults and subadults from other river systems (Bain 1997, Dovel and Berggren 1983b, Hatin *et al.* 2007, McCord *et al.* 2007). Once subadult Atlantic sturgeon have reached maturity (*i.e.*, adult stage), they will remain in marine or estuarine waters that are typically less than 50 meters deep, only returning far upstream to the spawning areas when they are ready to spawn (ASSRT 2007, Bain 1997, Breece *et al.* 2016, Dunton *et al.* 2012, 2015, Savoy and Pacileo 2003). Diets of adult and migrant subadult Atlantic sturgeon include gastropods, annelids (Polychaetes and Oligochaetes), crustaceans, and fish such as sand lance (ASSRT 2007, Bigelow and Schroeder 1953b, Guilbard *et al.* 2007, Savoy 2007).

Marine and Coastal Distribution

Based on fishery-independent, fishery dependent, tracking, and tagging data, Atlantic sturgeon appear to primarily occur inshore of the 50 meter depth contour (Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Laney *et al.* 2007, O'Leary *et al.* 2014, Stein *et al.* 2004a, b, Waldman *et al.* 2013, 2015a, Wirgin *et al.* 2015b). However, they are not restricted to these depths and excursions into deeper (*e.g.*, 75 m) continental shelf waters have been documented (Colette and Klein-MacPhee 2002, Collins and Smith 1997, Dunton *et al.* 2010, Erickson *et al.* 2011, Stein *et al.* 2004b, Timoshkin 1968). Data from fishery-independent surveys and tagging and tracking studies also indicate that some Atlantic sturgeon may undertake seasonal movements along the coast (Dunton *et al.* 2010, Erickson *et al.* 2011, Hilton *et al.* 2016, Oliver *et al.* 2013, Post *et al.* 2014, Wippelhauser 2012). For instance, studies found that 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; while, in the summer and fall, Atlantic sturgeon concentrations shifted to the northern portion of the Mid-Atlantic Bight at depths less than 20 meters (Erickson *et al.* 2011).

In the marine range, several marine aggregation areas occur adjacent to estuaries and/or coastal features formed by bay mouths and inlets along the U.S. eastern seaboard (*i.e.*, waters off North Carolina, Chesapeake Bay; Delaware Bay; New York Bight; Massachusetts Bay; Long Island Sound; and Connecticut and Kennebec River Estuaries). Depths in these areas are generally no greater than 25 meters (Bain *et al.* 2000, Dunton *et al.* 2010, Erickson *et al.* 2011, Laney *et al.* 2007, O'Leary *et al.* 2014, Oliver *et al.* 2013, Savoy and Pacileo 2003, Stein *et al.* 2004b, Waldman *et al.* 2013, Wippelhauser 2012, Wippelhauser and Squiers 2015). Although additional studies are still needed to clarify why Atlantic sturgeon aggregate at these sites, there is some indication that they may serve as thermal refuge, wintering sites, or marine foraging areas (Dunton *et al.* 2010, Erickson *et al.* 2011, Stein *et al.* 2004b).

Water temperature plays a primary role in triggering the timing of spawning migrations (Hilton *et al.* 2016). 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) (Hilton *et al.* 2016), andremain 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). Females may leave the estuary and travel to other coastal estuaries until outmigration to marine waters in the fall (Bain 1997, Bain *et al.* 2000, Balazik *et al.* 2012a, Breece *et al.* 2013, Dovel and Berggren 1983b, Greene *et al.* 2009, Hatin *et al.* 2002, NMFS 2017a, Smith 1985, Smith *et al.* 1982). Following spawning, males move downriver to the lower estuary and remain there until outmigration in the fall (Bain 1997, Bain *et al.* 2000, Balazik *et al.* 2012a, Breece *et al.* 2013, Dovel and Berggren 1983b, Greene *et al.* 2009, Hatin *et al.* 2002, Ingram *et al.* 2019, Smith 1985, Smith *et al.* 1982).

Population dynamics

A population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) trawl surveys (Kocik *et al.* 2013).[9] For this Opinion, we are relying on the population estimates derived from the NEAMAP swept area biomass assuming a 50 percent catchability (*i.e.*, net efficiency x availability) rate. We consider that the NEAMAP surveys sample an area utilized by Atlantic sturgeon, but do not sample all the locations and times where Atlantic sturgeon are present. We also consider that the trawl net captures some, but likely not all, of the Atlantic sturgeon present in the sampling area. Therefore, we assume that net efficiency and the fraction of the population exposed to the NEAMAP surveys in combination result in a 50 percent catchability (NMFS 2013a). The 50 percent catchability assumption reasonably accounts 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. As these estimates are derived directly from empirical data with fewer assumptions than have been required to model Atlantic sturgeon populations to date, we believe these estimates continue to serve as the best available information. Based on the above approach, the overall abundance of Atlantic sturgeon in U.S. Atlantic waters is estimated to be 67,776 fish (see Table 16 in Kocik *et al.* 2013). Based on genetic frequencies of occurrence in the sampled area, this overall population estimate was subsequently partitioned by DPS (Table 15). Given the proportion of adults to subadults in the NMFS NEFSC observer data (approximate ratio of 1:3), we have also estimated the number of adults and subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults, because it only considers

[9] Since fall 2007, NEAMAP trawl surveys (spring and fall) have been conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet). Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

those subadults that are of a size that are present and vulnerable to capture in commercial trawl and gillnet gear in the marine environment.

The NEAMAP-based estimates do not include young-of-the-year (YOY) fish and juveniles in the rivers. The NEAMAP surveys are conducted in waters that include the preferred depth ranges of subadult and adult Atlantic sturgeon and take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. However, the estimated number of subadults in marine waters is a minimum count because it only considers those subadults that are captured in a portion of the action area and are present in the marine environment, which is only a fraction of the total number of subadults. In regards to adult Atlantic sturgeon, the estimated population in marine waters is also a minimum count as the NEAMAP surveys sample only a portion of the action area, and therefore a portion of the Atlantic sturgeon's range.

Table 15. Calculated population estimates based upon the NEAMAP survey swept area model, assuming 50 percent efficiency.

DPS	Estimated Ocean Population Abundance	Estimated Ocean Population of Adults	Estimated Ocean Population of Subadults (of size vulnerable to capture in fisheries)
GOM	7,455	1,864	5,591
NYB	34,567	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	679	170	509

Precise estimates of population growth rate (intrinsic rates) are unknown for the five listed DPSs of Atlantic sturgeon due to a lack of long-term abundance data. The ASMFC (2017) stock assessment referenced a population viability assessment (PVA) that was done to determine population growth rates for the five DPSs based on a few long-term survey programs, but most results were statistically insignificant or utilized a model that would not converge. In any event, the population growth rates reported from that PVA ranged from -1.8 percent to 4.9 percent (ASMFC 2017).

The genetic diversity of Atlantic sturgeon throughout its range has been well-documented (ASSRT 2007, Bowen and Avise 1990, O'Leary *et al.* 2014, Ong *et al.* 1996, Waldman *et al.* 1996, Waldman and Wirgin 1998). Overall, these studies have consistently found populations to be genetically diverse, and the majority can be readily differentiated. Relatively low rates of gene flow reported in population genetic studies (Fritts *et al.* 2016, Savoy *et al.* 2017, Wirgin *et al.* 2002) indicate that Atlantic sturgeon return to their natal river to spawn, despite extensive mixing in coastal waters.

Determination of DPS Composition in the Action Area

The range of all five listed DPSs extends from Canada through Cape Canaveral, Florida. All five DPSs use the action area. We decided not to use the most recent published mixed stock analysis from (Kazyak *et al.* 2021), because the percentages were based on genetic sampling of Atlantic sturgeon that were encountered across the U.S. Atlantic coast. Instead, we use the percentages from (Damon-Randall *et al.* 2013) for subadults and adults because their analysis is more consistent in habitat and geography to the action area defined in this biological opinion.

The proposed action takes place in the Delaware River and estuary. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Delaware River, and thereby, in the action area, will have originated from the Delaware River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Delaware River and estuary would not be limited to just individuals originating from the NYB DPS. Based on mixed-stock analysis, we have determined that subadult and adult Atlantic sturgeon in the action area likely originate from the five DPSs at the following frequencies: Gulf of Maine 7 percent; NYB 58 percent; Chesapeake Bay 18 percent; South Atlantic 17 percent; and Carolina 0.5 percent. These percentages are largely based on genetic sampling of individuals (n=105) sampled in directed research targeting Atlantic sturgeon along the Delaware Coast, just south of Delaware Bay (described in detail in Damon-Randall *et al.* 2013). This is the closest sampling effort (geographically) to the action area for which mixed stock analysis results are available. Because the genetic composition of the mixed stock changes with distance from the rivers of origin, it is appropriate to use mixed stock analysis results from the nearest sampling location. Therefore, this represents the best available information on the likely genetic makeup of individuals occurring in the action area.

We also considered information on the genetic makeup of subadults and adults captured within the Delaware River. However, we only have information on the assignment of these individuals to the river of origin and do not have a mixed stock analysis for these samples. The river assignments are very similar to the mixed stock analysis results for the Delaware Coastal sampling, with the Hudson/Delaware accounting for 55-61 percent of the fish, James River accounting for 17-18 percent, Savannah/Ogeechee/Altamaha 17-18 percent, and Kennebec 9-11 percent. The range in assignments considers the slightly different percentages calculated by treating each sample individually versus treating each fish individually (some fish were captured in more than one of the years during the three-year study). Carolina DPS origin fish have rarely been detected in samples taken in the Northeast and are not detected in either the Delaware Coast or in-river samples noted above. However, mixed stock analysis from one sampling effort (i.e., Long Island Sound, n=275), indicates that approximately 0.5 percent of the fish sampled were Carolina DPS origin. Additionally, 4 percent of Atlantic sturgeon captured incidentally in commercial fisheries along the U.S. Atlantic coast north of Cape Hatteras, and genetically analyzed, belong to the Carolina DPS. Because any Carolina origin sturgeon that were sampled in Long Island Sound could have swam through the action area on their way between Long Island Sound and their rivers of origin, it is reasonable to expect that 0.5 percent of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. The genetic assignments have a plus/minus 5 percent confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2013).

The marine range of U.S. Atlantic sturgeon extends from Labrador, Canada, to Cape Canaveral, Florida. As Atlantic sturgeon travel long distances in these waters, all five DPSs of Atlantic sturgeon have the potential to be anywhere in this marine range. Results from genetic studies show that, regardless of location, multiple DPSs can be found at any one location along the Northwest Atlantic coast, although the Hudson River population from the New York Bight DPS dominates (ASMFC 2017, 2019, ASSRT 2007, Dadswell 2006, Dovel and Berggren 1983b, Dunton *et al.* 2012, Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Kynard *et al.* 2000, Laney *et al.* 2007, O'Leary *et al.* 2014, Stein *et al.* 2004b, Waldman *et al.* 2013, Wirgin *et al.* 2015a, Wirgin *et al.* 2012).

Status

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 (ASSRT 2007). There are currently 39 rivers and two creeks that are specific occupied areas designated as critical habitat for Atlantic sturgeon (NMFS NMFS (National Marine Fisheries Service) 2017a, 2017b). The decline in abundance of Atlantic sturgeon has been attributed primarily to the large U.S. commercial fishery, which existed for the Atlantic sturgeon through the mid 1990s in some states. Based on management recommendations in the interstate fishery management plan (ISFMP), adopted by the Atlantic States Marine Fisheries Commission (the Commission) in 1990, commercial harvest in Atlantic coastal states was severely restricted and ultimately eliminated from all states (ASMFC 1998). In 1998, the Commission placed a 20-40 year moratorium on a coastwide basis to allow 20 consecutive cohorts of females to reach sexual maturity and spawn, which will facilitate restoration of the age structure. The 20- to 40-year moratorium was put in place because they considered the median maturity of female Atlantic sturgeon to be about age 18 and, therefore, it was expected that it could take up to 38 years before 20 subsequent year classes of adult females is established (ASMFC 1998). In 1999, NMFS closed the Exclusive Economic Zone to Atlantic sturgeon retention, pursuant to the Atlantic Coastal Act (64 FR 9449; February 26, 1999). However, all state fisheries for sturgeon were closed prior to this.

The most significant threats to Atlantic sturgeon are vessel strikes, bycatch in commercial fisheries, habitat changes, impeded access to historical habitat by dams and reservoirs in the south, degraded water quality; and reduced water quantity. A first-of-its-kind climate vulnerability assessment, conducted on 82 fish and invertebrate species in the Northeast U.S. Shelf, concluded that Atlantic sturgeon from all five DPSs were among the most vulnerable species to global climate change (Hare *et al.* 2016a).

The Commission completed an Atlantic sturgeon benchmark stock assessment in 2017 that considered the status of each DPS individually, as well as all five DPSs collectively as a single unit (ASMFC 2017). The assessment concluded all five DPSs of Atlantic sturgeon, as well as each individual DPS remain depleted relative to historic abundance. The assessment also concluded that the population of all five DPSs together appears to be recovering slowly since implementation of a complete moratorium on directed fishing and retention in 1998. However, there were only two individual DPSs, the New York Bight DPS and Carolina DPS, for which there was a relatively high probability that abundance of the DPS has increased since the implementation of the 1998 fishing moratorium. There was considerable uncertainty expressed in the stock assessment and in its peer review report. For example, new information suggests that these conclusions about the New York Bight DPS primarily reflect the status and trend of only the DPS's Hudson River spawning population. In addition, there was a relatively high probability that mortality for animals of the Gulf of Maine DPS and the Carolina DPS exceeded the mortality threshold used for the assessment. Yet, the stock assessment notes that it was not clear if: (1) the percent probability for the trend in abundance for the Gulf of Maine DPS is a reflection of the actual trend in abundance or of the underlying data quality for the DPS; and, (2) the percent probability that the Gulf of Maine DPS exceeds the mortality threshold actually reflects lower survival or was due to increased tagging model uncertainty owing to low sample sizes and potential emigration. Therefore,while Atlantic sturgeon populations may be showing signs of slow recovery since the 1998 and 1999 moratoriums when all five DPSs are considered collectively, these trends are not necessarily reflected with individual DPSs and there is considerable uncertainty related to population trends (ASMFC 2017).

Critical Habitat

Critical habitat has been designated for the five DPSs of Atlantic sturgeon (82 FR 39160, August 17, 2017) in rivers of the eastern United States.

Recovery Goals

Recovery Plans have not yet been drafted for any of the Atlantic sturgeon DPSs. A recovery outline (see https://www.fisheries.noaa.gov/resource/document/recovery-outline-atlantic-sturgeon-distinct-population-segments) has been developed as interim guidance to direct recovery efforts, including recovery planning, until a full recovery plan is approved.

5.2.2.2 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS of Atlantic sturgeon includes Atlantic sturgeons spawned in the watersheds that drain into the Gulf of Maine from the Maine/Canadian border and extending southward to Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Penobscot, Kennebec, Androscoggin, Sheepscot, and Merrimack Rivers (ASSRT 2007). Spawning habitat is available and accessible in the Penobscot, Androscoggin, Kennebec, Merrimack, and Piscataqua (inclusive of the Cocheco and Salmon Falls rivers) rivers. Spawning has been documented in the Kennebec River. During the study period of 2009-2011, eight sturgeon, including one male in spawning condition, were also captured in the Androscoggin River estuary, which suggests that spawning may be occurring in the Androscoggin River as well (Wippelhauser *et al.* 2017). However, additional evidence, such as capture of a spawning female, sturgeon eggs or larvae, is not yet available to confirm that spawning for the Gulf of Maine DPS is occurring in that river (NMFS 2018).

Studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS as well as likely throughout the entire range (ASSRT 2007, Fernandes *et al.* 2010).

Bigelow and Schroeder (1953a) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (ASMFC 1998, NMFS (National Marine Fisheries Service) and U.S. FWS (U.S. Fish and Wildlife Service) 1998, Wippelhauser *et al.* 2017). 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 four ripe males and one ripe female captured on July 26, 1980; (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 (Atlantic States Marine Fisheries Commission) 2007, NMFS (National Marine Fisheries Service) and U.S. FWS (U.S. Fish and Wildlife Service) 1998); and (4) the capture of three Atlantic sturgeon larvae between rkm 72 and rkm 75 in July 2011 (Wippelhauser *et al.* 2017). The low salinity values for waters above Merrymeeting Bay are consistent with values found in 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 17^{th} century (Squiers *et al.* 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.* 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon bycatch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state-managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (ASMFC 2007, Stein *et al.* 2004a). Subadults and adults are killed as a result of bycatch in fisheries authorized under Northeast Fishery Management Plans (FMPs). At this time, we are not able to quantify the impacts from this and other threats or estimate the number of individuals killed as a result of 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 consequences to habitat.

Connectivity is disrupted by the presence of dams on some 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 the 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 tracking of spawning condition Atlantic sturgeon downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam and the Great Works Dam, sturgeon can now travel as far upstream as the Milford Dam. Atlantic sturgeon primarily occur within the mesohaline reach of the river, particularly in areas with high densities of sturgeon prey which means that the Penobscot River is likely an important foraging area for Atlantic sturgeon belonging to the Gulf of Maine DPS (Altenritter *et al.* 2017). There is no current evidence that spawning is occurring in the Penobscot River. Acoustic tag detections suggest that the adults that forage in the Penobscot River travel to the Kennebec River to spawn (Altenritter *et al.* 2017). The Essex Dam on the Merrimack River blocks access to approximately 58 percent of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (EPA 2008, 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.

The threat of vessel strike appears to be less for Atlantic sturgeon belonging to the Gulf of Maine DPS compared to the New York Bight or Chesapeake Bay DPSs based on the number of Atlantic sturgeon vessel struck carcasses that are found in Gulf of Maine rivers, and given the differences in vessel activity in the respective natal rivers. Nevertheless, some strikes do occur within the Gulf of Maine and sturgeon belonging to the Gulf of Maine can also be struck in other areas of their range including higher salinity waters of the Hudson River Estuary, Delaware River Estuary, and Chesapeake Bay.

We described in the listing rule that potential changes in water quality as a result of global climate change (temperature, salinity, dissolved oxygen, contaminants, etc.) in rivers and coastal waters inhabited by Atlantic sturgeon will likely affect riverine populations, and we expected these effects to be more severe for southern portions of the U.S. range. However, new information shows that the Gulf of Maine is one of the fastest warming areas of the world as a result of global climate change (Brickman *et al.* 2021, Pershing *et al.* 2015). Markin and Secor (2020) further demonstrate the consequences of temperature on the growth rate of juvenile Atlantic sturgeon, and informs how global climate change may impact growth and survival of Atlantic sturgeon across their range. Their study showed that all juvenile Atlantic sturgeon had increased growth rate with increased water temperature regardless of their genetic origins. However, based on modeling and water temperature data from 2008 to 2013, they also determined that there is an optimal water temperature range, above and below which juveniles experience a slower growth rate, and they further considered how changes in growth rate related to warming water temperatures associated with global climate change might affect juvenile survival given the season (*e.g.*, spring or fall) in which spawning currently occurs.

There are no abundance estimates for the Gulf of Maine DPS or for the Kennebec River spawning population. Wippelhauser and Squiers (2015) reviewed the results of studies conducted in the Kennebec River System from 1977-2001. In total, 371 Atlantic sturgeon were captured, but the abundance of adult Atlantic sturgeon in the Kennebec spawning population could not be estimated because too few tagged fish were recaptured (*i.e.*, 9 of 249 sturgeon).

Another method for assessing the number of spawning adults is through determinations of effective population size[10], which measures how many adults contributed to producing the next generation based on genetic determinations of parentage from the offspring. Effective population size is always less than the total abundance of a population because it is only a measure of parentage, and it is expected to be less than the total number of adults in a population because not all adults successfully reproduce. Measures of effective population size are also used to inform whether a population is at risk for loss of genetic diversity and inbreeding. The effective population size of the Gulf of Maine DPS was assessed in two studies based on sampling of adult Atlantic sturgeon captured in the Kennebec River in multiple years. The studies yielded very

[10] Effective Population Size is the number of individuals that effectively participates in producing the next generation. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/effective-population-size. It is less than the total number of individuals in the population.

similar results which were an effective population size of: 63.4 (95% CI=47.3-91.1) (ASMFC 2017) and 67 (95% CI=52.0–89.1) (Waldman *et al.* 2019).

Summary of the Gulf of Maine DPS

Spawning for the Gulf of Maine DPS is known to occur in Kennebec and may occur Androscoggin. Spawning may be occurring in other rivers, such as the Penobscot, but has not been confirmed. In the Stock Assessment, the Commission concluded that the abundance of the Gulf of Maine DPS is "depleted" relative to historical levels and there is a 51 percent probability that abundance of the Gulf of Maine DPS has increased since implementation of the 1998 fishing moratorium (ASMFC 2017). The Commission also noted that the Gulf of Maine is particularly data poor among all five DPSs 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). The Saco River supports a large aggregation of Atlantic sturgeon that forage on sand lance in Saco Bay and within the first few kilometers (km) of the Saco River, primarily from May through October. Detections of acoustically-tagged sturgeon indicate that both adult and subadult Atlantic sturgeon use the area for foraging and come back to the area year after year (Little 2013, Novak *et al.* 2017). Some sturgeon also overwinter in Saco Bay (Hylton *et al.* 2018, Little 2013) which suggests that the river provides important wintering habitat as well, particularly for subadults. However, none of the new information indicates recolonization of the Saco River for spawning. It remains questionable whether sturgeon larvae could survive in the Saco River even if spawning were to occur because of the presence of the Cataract Dam at rkm 10 of the river (Little 2013) which limits access to the freshwater reach. Some sturgeon that spawn in the Kennebec have subsequently been detected foraging in the Saco River and Bay (Novak *et al.* 2017, Wippelhauser *et al.* 2017).

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 Gulf of Maine DPS are not commonly taken as bycatch in areas south of Chatham, Massachusetts, with only 8 percent (*e.g.*, 7 of 84 fish) of interactions observed in the New York 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). Thus, a significant number of the GOM DPS fish appear to migrate north into Canadian waters where they may be subjected to a variety of threats including bycatch. Dadswell *et al.* (2016) describes characteristics of the seasonal aggregation of sturgeon in the Bay of Fundy. Dadswell et al. does not identify the natal origin of each of the 1,453 Atlantic sturgeon captured and sampled for their study. However, based on Wirgin *et al.* (2012) and Stewart *et al.* (2017), NMFS considers the results of Dadswell et al. as representative of the movement of the Gulf of Maine DPS of Atlantic sturgeon. Dadswell et al. determined subadult and adult Atlantic sturgeon occur seasonally (approximately May to September) in the Bay of Fundy for foraging, and many return in consecutive years. Fork length (FL) of the 1,453 sampled sturgeon ranged from 45.8 to 267 cm, but the majority (72.5 percent) were less than 150 cm FL. The age of the sturgeon (*i.e.*, 4 to 54 years old) is also indicative of the two different life stages. Detailed seasonal movements of sturgeon to and from the Bay of Fundy are described in Beardsall *et al.* (2016).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman 1997, Brown and Murphy 2010, ASMFC 2007, Kahnle *et al.* 2007). We have 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.

5.2.2.3 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 (including bays and sounds) 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 there is no recent evidence (within the last 15 years) of spawning in the Taunton River (ASSRT 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007, Savoy 2007, Wirgin and King 2011).

In 2014, the Connecticut Department of Energy and Environmental Protection (CT DEEP) captured Atlantic sturgeon in the river that, based on their size, had to be less than one year old. Therefore, given the established life history patterns for Atlantic sturgeon which include remaining in lower salinity water of their natal river estuary for more than one year, the sturgeon were likely spawned in the Connecticut River. However, genetic analysis for 45 of the smallest fish (ranging from 22.5 to 64.0 cm TL) indicated that the sturgeon were most closely related to Atlantic sturgeon belonging to the South Atlantic DPS (Savoy *et al.* 2017). The conventional thinking is that the Connecticut River was most likely to be recolonized by Atlantic sturgeon from the Hudson River spawning population because: it is the closest of the known spawning rivers to the Connecticut; the most robust of all of the spawning populations; and, occurs within the same, unique, ecological setting. Furthermore, the majority of the Atlantic sturgeon that aggregate in the Lower Connecticut River and Long Island Sound originate from the New York

Bight DPS (primarily the Hudson River spawning population) whereas less than 10 percent originate from the South Atlantic DPS (Waldman *et al.* 2013). The genetic results for the juvenile sturgeon are, therefore, counter to prevailing information regarding straying and the affinity of Atlantic sturgeon for natal homing. The genetic analyses of the juvenile sturgeon also showed that many (*i.e.*, 82 percent) were full siblings which means that relatively few adults contributed to this cohort. The CT DEEP is conducting a multiyear investigation to further inform the status and origin of Atlantic sturgeon spawning in the river. At this time, we are not able to conclude whether the juvenile sturgeon detected are indicative of sustained spawning in the river or whether they were the result of a single spawning event due to unique straying of the adults from the South Atlantic DPS's spawning rivers.

There are no abundance estimates for the entire New York Bight DPS or for the entirety of the (*i.e.*, all age classes) the Hudson River or Delaware River populations. There are, however, some estimates for specific life stages (*e.g.*, natal juvenile abundance, spawning run abundance, and effective population size). Using side scan sonar technology in conjunction with detections of previously tagged Atlantic sturgeon, Kazyak *et al.* (2020) estimated the 2014 Hudson River spawning run size to be 466 sturgeon (95 percent CRI = 310-745). Based on genetic analyses of two different life stages, effective population size for the Hudson River spawning population has been estimated to be 198 (95 percent CI=171.7-230.7; (O'Leary *et al.* 2014)) based on sampling of subadults[11] captured off of Long Island across multiple years, and 156 (95 percent CI=138.3-176.1; (Waldman *et al.* 2019)) based on sampling of natal juveniles in multiple years. It has also been estimated at 144.2 (95 percent CI=82.9-286.6) based on samples from a combination of juveniles and adults (ASMFC 2017). Estimates for the Delaware River spawning population from the same studies were 108.7 (95 percent CI=74.7-186.1; (O'Leary *et al.* 2014)), 40 (95 percent CI=34.7-46.2; (Waldman *et al.* 2019)), and 56.7 (95 percent CI=42.5-77.0) (ASMFC 2017). The difference in effective population size for the Hudson and Delaware River spawning populations across both studies support that the Hudson River spawning population is the more robust of the two spawning groups. This conclusion is further supported by genetic analyses that demonstrated Atlantic sturgeon originating from the Hudson River spawning population were more prevalent in mixed aggregations than sturgeon originating from the Delaware River spawning population, even when sampling occurred in areas and at times that targeted for adults belonging to the Delaware River spawning population (Kazyak *et al.* 2021, Wirgin *et al.* 2015a, Wirgin *et al.* 2015b). Waldman et al.'s calculations of maximum effective population size, and comparison of these to four other spawning populations outside of the New York Bight DPS further supports our previous conclusion that the Hudson River spawning population is more robust than the Delaware River spawning population and is likely the most robust of all of the U.S. Atlantic sturgeon spawning populations.

As described above, the CT DEEP determined that very few adults contributed to the juveniles found in the Connecticut River in 2014. Based on the genetic analysis of 45 of the captured

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[11] O'Leary et al. refer to the sampled fish as juveniles. However, we use the term "subadult" for immature Atlantic sturgeon that have emigrated from the natal river, and the term "juvenile" for immature fish that have not yet emigrated from the natal river.

juveniles, the effective population size for the Connecticut River was estimated to be 2.4 sturgeon (Savoy *et al.* 2017). As noted above, the CT DEEP is further investigating the presence of and origins for a spawning population in the Connecticut River.

For purposes of ESA section 7 consultations, we estimated adult and subadult abundance of the New York Bight DPS based on available information for the genetic composition and the estimated abundance of Atlantic sturgeon in marine waters (Damon-Randall *et al.* 2013, Kocik *et al.* 2013). We concluded that subadult and adult abundance of the New York Bight DPS was 34,566 sturgeon (NMFS 2013a). This number encompasses many age classes since subadults can be as young as one year old when they first enter the marine environment, and adults can live as long as 64 years (Balazik *et al.* 2012b, Hilton *et al.* 2016). For example, in their study of Atlantic sturgeon captured in the geographic New York Bight, Dunton *et al.* (2016) determined that 742 of the Atlantic sturgeon captured represented 21 estimated age classes and that, individually, the sturgeon ranged in age from 2 to 35 years old.

The Commission concluded for their 2017 Atlantic Sturgeon Stock Assessment that abundance of the New York Bight DPS is "depleted" relative to historical levels but, there is a relatively high probability (75 percent) that the New York Bight DPS abundance has increased since the implementation of the 1998 fishing moratorium, and a 31 percent probability that mortality for the New York Bight DPS exceeds the mortality threshold used for the assessment (ASMFC 2017). However, as noted above, the Commission noted considerable uncertainty related to trend data. Moreover, new information suggests that the Commission’s conclusions primarily reflect the status and trend of only the DPS’s Hudson River spawning population. The ASMFC did not estimate abundance of the New York Bight DPS or otherwise quantify the trend in abundance because of the limited available information

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 consequences of bridge construction (including the 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 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.

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 Hudson and Delaware Rivers. Similar to the Hudson River, there is currently not enough information to determine a population trend for the Delaware River population.

Based on genetic analyses, Atlantic sturgeon belonging to the New York Bight DPS have been identified among those captured in the Bay of Fundy, Canada as well as in U.S. waters that include Long Island Sound, the lower Connecticut River, and in marine waters off of western Long Island, New Jersey, Delaware, Virginia, and North Carolina. However, the New York Bight DPS was more prevalent relative to the other DPSs in Mid-Atlantic marine waters, bays, and sounds (Dunton *et al.* 2012, Waldman *et al.* 2013, Wirgin *et al.* 2015b, 2018). These findings support the conclusion of Wirgin *et al.* (2015b) that natal origin influences the distribution of Atlantic sturgeon in the marine environment, and suggest that some parts of its marine range are more useful to and perhaps also essential to the New York Bight DPS.

Further evidence was presented by Erickson *et al.* (2011). Thirteen of the fifteen adult Atlantic sturgeon, that they captured and tagged in the tidal freshwater reach of the Hudson River (*i.e.*, belonging to the Hudson River spawning population), remained in the Mid-Atlantic Bight during the 6 months to 1 year time period of data collection. Of the remaining two fish, one traveled as far north as Canadian waters where its tag popped up in June, nearly one year after being tagged. The second fish traveled south beyond Cape Hatteras[12] before its tag popped up, about 7 months after being tagged. Collectively, all of the tagged sturgeon occurred in marine and estuarine Mid-Atlantic Bight aggregation areas that have been the subject of sampling used for the genetic analyses, including in waters off of Long Island, the coasts of New Jersey and Delaware, the Delaware Bay and the Chesapeake Bay.

Breece *et al.* (2016) further investigated the distribution and occurrence of Atlantic sturgeon in the Mid-Atlantic Bight based on associated habitat features, as well as the habitat features associated with presence of adults in the Delaware River, and their distribution and movements within Delaware Bay. The research provides evidence of specific, dynamic habitat features that Atlantic sturgeon are sensitive to in their aquatic environments such as substrate composition and distance from the salt front in the river estuary, water depth and water temperature in Delaware Bay, and depth, day-of-year, sea surface temperature, and light absorption by seawater in marine waters (2017, 2018, Breece *et al.* 2013). Their model, based on the features identified for the marine environment, was highly predictive of Atlantic sturgeon distribution in the Mid-Atlantic Bight from mid-April through October. Since the majority of Atlantic sturgeon occurring in the Mid-Atlantic Bight belong to the New York Bight DPS, these studies provide: (1) new information describing the environmental factors that influence the presence and movements of New York Bight DPS Atlantic sturgeon in the Mid-Atlantic Bight, the Delaware Bay and the Delaware River; (2) a modeling approach for predicting occurrence and distribution of New York Bight DPS Atlantic sturgeon, particularly in the spring through early fall; and, (3) information to better assess consequences to the New York Bight DPS given known, expected, or predicted changes to their habitat.

Summary of the New York Bight DPS

[12] As explained in Erickson *et al.* (2011), relocation data for both of these fish were more limited for different reasons. Therefore, more exact locations could not be determined.

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 is uncertainty related to trends inabundance for the New York Bight DPS (ASMFC 2017, ASMFC 2010, Greene *et al.* 2009). 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 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, global climate change, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the New York Bight DPS.

Additional information is available that informs the consequences of climate change on the New York Bight DPS. There is already evidence of habitat changes in the Delaware River from other anthropogenic activities. Modeling by Breece *et al.* (2013) demonstrates that the Delaware River salt front is likely to advance even further upriver with climate change, which would reduce the amount of transitional salinity habitat available to natal juveniles. Coupled with other climate and anthropogenic changes, such as drought and channel deepening, the already limited amount of tidal freshwater habitat available for spawning could be reduced and the occurrence of low dissolved oxygen within early juvenile rearing habitat could increase. As evidenced by the studies of Hare *et al.* (2016a) and Balazik *et al.* (2010), the Delaware spawning population is unlikely to redistribute to another river even if their habitat in the Delaware River is increasingly insufficient to support successful spawning and rearing for the New York Bight DPS due to climate change.

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (ASMFC 2007, Stein *et al.* 2004a). Currently available estimates indicate that at least 4 percent of adults may be killed as a result of bycatch in fisheries authorized under Northeast FMPs. Based on mixed stock analysis results presented by Wirgin and King (2011). Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid-Atlantic Bight region were sturgeon from the New York Bight DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1-2 percent were from the New York Bight DPS (Wirgin *et al.* 2012). 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, and four fish were entrained in the Delaware River during maintenance and deepening activities in 2017 and 2018. At this time, we do not have any additional 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 consequences 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 (EPA 2008, 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 and Bay. One-hundred and one mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2005 to 2019, and at least 64 of these fish were large adults and subadults. Based on evidence of Atlantic sturgeon vessel strikes since the listing, it is now apparent that vessel strikes are also occurring in the Hudson River. For example, the New York DEC reported that at least 17 dead Atlantic sturgeon with vessel strike injuries were found in the river in 2019 of which at least 10 were 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 (Boreman 1997, Brown *et al.* 2012, ASMFC 2007, Kahnle *et al.* 2007). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. We 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.

5.2.2.4 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay (CB) DPS of Atlantic sturgeon includes Atlantic sturgeon spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters (including bays and sounds) from the Delaware-Maryland border at Fenwick Island to Cape Henry, Virginia. The marine range of Atlantic sturgeon from the CB DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the CB DPS and the adjacent portion of the marine range are shown in Figure 11. 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, amongst the additional spawning populations for the Chesapeake Bay DPS, and there is evidence that most of the Chesapeake Bay DPS spawning populations spawn in the late summer to fall (hereafter referred to as “fall spawning”) rather than in the spring. Fall spawning activity has been documented in the newly discovered spawning populations in the Pamunkey River, a tributary of the York River, and in Marshyhope Creek, a tributary of the Nanticoke River (Hager *et al.* 2014, Richardson and Secor 2016, Secor *et al.* 2021). The James River is currently the only river of the Chesapeake Bay DPS where evidence suggests there is both spring and fall spawning with separate spawning populations. The results of genetic analyses show that there is some limited gene flow between the populations but, overall, the spawning populations are genetically distinct (Balazik *et al.* 2017b, Balazik *et al.* 2012a, Balazik and Musick 2015). New detections of acoustically-tagged adult Atlantic sturgeon along with historical evidence suggests that Atlantic sturgeon belonging to the Chesapeake Bay DPS may be spawning in the Mattaponi and Rappahannock rivers as well (ASMFC 2017, Hilton *et al.* 2016, Kahn 2019). However, information for these populations is limited and the research is ongoing.

Age to maturity for CB 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 five 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.* 1988). Therefore, age at maturity for Atlantic sturgeon of the CB DPS likely falls within these values.

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

Decreased water quality also threatens Atlantic sturgeon of the CB DPS, especially since the Chesapeake Bay system is vulnerable to the consequences of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface-to-volume ratio, and strong stratification during the spring and summer months (ASMFC 1998, ASSRT 2007, EPA 2008, Pyzik *et al.* 2004). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor 2005, 2010). Heavy industrial development during the 20th century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery.

Although there have been improvements in the some areas of the Bay's health, the ecosystem remains in poor condition. In 2020, the Chesapeake Bay Foundation gave the overall health index of the Bay a grade of 32 percent (D+) based on the best available information about the Chesapeake Bay for indicators representing three major categories: pollution, habitat, and fisheries (Chesapeake Bay Foundation 2020).. While 32 percent is one percent lower than the state of the Bay score in 2018, this was a 18.5 percent increase from the first State of the Bay report in 1998 which gave the Bay a score of 27 percent (D). According to the Chesapeake Bay Foundation, the modest gain in the health score was due to a relatively stable adult blue crab population, promising results from oyster reef restoration, less nitrogen and phosphorous in the water, a smaller dead zone, and improvements in water clarity as highlighted below:

- Monitoring data indicated that the 2020 dead zone was the seventh smallest in the past 35 years,
- Three decades of data recently reviewed by scientists at the Chesapeake Bay Program revealed that, although waters in the Bay may still look cloudy to the human eye, light attenuation trends are improving—in other words, more light is penetrating through the water due to changes in the types of particles in the water that block sunlight,
- Nitrogen and phosphorus pollution from the Susquehanna and Potomac Rivers was well below the 10-year average, partially a reflection of below-average precipitation, From 2019-2020, Maryland and Virginia completed 343 and 21 acres of oyster reef restoration projects in the Little Choptank River and the Eastern Branch of the Elizabeth River, respectively, and
- Although the most recent population estimate for blue crab declined slightly, it remained within the bounds fishery scientists consider healthy(Chesapeake Bay Foundation 2020).

At this time we do not have sufficient information to quantify the extent that degraded water quality affects 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 2005-2007. More than 100 Atlantic sturgeon carcasses have been salvaged in the James River since 2007 and additional carcasses were reported but could not be salvaged (Greenlee *et al.* 2019). Many of the salvaged carcasses had evidence of a fatal vessel strike. In addition, vessel struck Atlantic sturgeon have been found in other parts of the Chesapeake Bay DPS's range including in the York and Nanticoke river estuaries, within Chesapeake Bay, and in marine waters near the mouth of the Bay since the DPS was listed as endangered (NMFS Sturgeon Salvage Permit Reporting; Secor *et al.* 2021). The best available information supports the conclusion that sturgeon are struck by small (*e.g.*, recreational) as well as large vessels. NMFS has only minimum counts of the number of Atlantic sturgeon that are struck and killed by vessels because only the sturgeon that are found dead with evidence of a vessel strike are counted. New research, including a study conducted along the Delaware River that intentionally placed Atlantic sturgeon carcasses in areas used by the public, suggests that most Atlantic sturgeon carcasses are not found and, when found, many are not reported to NMFS or to our sturgeon salvage co-investigators (Balazik, pers. comm. in ASMFC 2017, Balazik *et al.* 2012d, Fox *et al.* 2020). There have been an increased number of vessel struck sturgeon reported in the James River in recent years (ASMFC 2017). However, it is unknown to what extent the numbers reflect increased carcass reporting.

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

Summary of the Chesapeake Bay DPS

There are no abundance estimates for the entire Chesapeake Bay DPS or for the spawning populations in the James River or the Nanticoke River system. Spawning for the CB DPS is known to occur in only the James and Pamunkey Rivers and in Marshyhope Creek. Spawning may be occurring in other rivers, such as the York, Rappahannock and Potomac, but has not been confirmed for any of those. 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.

Based on research captures of tagged adults, an estimated 75 Chesapeake Bay DPS Atlantic sturgeon spawned in the Pamunkey River in 2013 (Kahn *et al.* 2014). More recent information provided annual run estimates for the Pamunkey River from 2013 to 2018. The results suggest a spawning run of up to 222 adults but with yearly variability, likely due to spawning periodicity (Kahn 2019).

Research in the Nanticoke River system suggests a small adult population based on a small total number of captures (*i.e.*, 26 sturgeon) and the high rate of recapture across several years of study (Secor *et al.* 2021). By comparison, a total of 373 different adult-sized Atlantic sturgeon (*i.e.*, total count does not include recaptures of the same fish) were captured in the James River from 2009 through spring 2014 (Balazik and Musick 2015). This is a minimum count of the number of adult Atlantic sturgeon in the James River during the time period because capture efforts did not occur in all areas and at all times when Atlantic sturgeon were present in the river.

There are several estimates of effective population size for Atlantic sturgeon that are spawned in the James River although only one study examined the effective population size of both the spring and fall spawning populations. Nevertheless, the estimates of effective population size from separate studies and based on different age classes are similar. These are: 62.1 (95% CI=44.3-97.2) based on sampling of subadults captured off of Long Island across multiple years;

32 (95% CI=28.8-35.5) based on sampling of natal juveniles and adults in multiple years (Waldman *et al.* 2019); 40.9 (95% CI=35.6-46.9) based on samples from a combination of juveniles and adults, (ASMFC 2017); and, 44 (95% CI=26–79) and 46 (95% CI=32–71) for the spring and fall spawning populations, respectively, based on sampling of adults (Balazik *et al.* 2017b). There is a single estimate of 12.2 (95% CI = 6.7– 21.9) for the Nanticoke River system (Secor *et al.* 2021), and also a single estimate of 7.8 (95% CI=5.3-10.2) for the York River system based on samples from adults captured in the Pamunkey River (ASMFC 2017).

Some of the impact from the threats that facilitated the decline of the CB DPS have been removed (*e.g.*, directed fishing) or reduced as a result of improvements in water quality since passage of the CWA. 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 CB DPS of Atlantic sturgeon. Of the 35 percent of Atlantic sturgeon incidentally caught in the Bay of Fundy, about one percent were CB DPS fish (Wirgin *et al.* 2012). Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (Boreman 1997, ASMFC 2007, Kahnle *et al.* 2007). The CB 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.

5.2.2.5 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. The riverine range of the Carolina DPS and the adjacent portion of the marine range are shown in Figure 11. Sturgeon are commonly captured 40 miles offshore (D. Fox, Delaware State University, pers. comm.). Records providing fishery bycatch data by depth show the vast majority of Atlantic sturgeon bycatch via gillnets is observed in waters less than 50 meters deep (ASMFC 2007, Stein *et al.* 2004b), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms.

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. We determined spawning was occurring if YOY were observed or mature adults were present in freshwater portions of a system (Table 16). 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. Fish from the Carolina DPS likely use other river systems than those listed here for their specific life functions.

Table 16. Major rivers, tributaries, and sounds within the range of the Carolina DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

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

Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002, Secor 2002). Secor (2002) estimates that 8,000 adult females were present in South Carolina during that same time frame. Prior reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS. Currently, the Atlantic sturgeon spawning population in at least one river system within the Carolina DPS has been extirpated, with potential extirpation in an additional system. The abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, are estimated to be less than 3 percent of what they were historically (ASSRT 2007). We have estimated that there are a minimum of 1,356 Carolina DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters.

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast in the mid- to late 19th century, from which they have never rebounded. Continued bycatch of Atlantic sturgeon in commercial fisheries is an ongoing impact to the Carolina DPS. More robust fishery independent data on bycatch are available for the Northeast and Mid-Atlantic than in the Southeast where high levels of bycatch underreporting are suspected.

Though there are statutory and regulatory provisions that authorize reducing the impact of dams on riverine and anadromous species, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Water quality continues to be a problem in the Carolina DPS, even with existing controls on some pollution sources. Current regulatory regimes are not 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.).

Summary of the Status of the Carolina DPS of Atlantic Sturgeon

Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, this is hampered within the Carolina DPS by habitat alteration and bycatch. This DPS was severely depleted by past directed commercial fishing, and faces ongoing impacts and threats from habitat alteration or inaccessibility, bycatch, and the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch that have prevented river populations from rebounding and will prevent their recovery.

The presence of dams has resulted in the loss of more than 60 percent of the historical sturgeon habitat on the Cape Fear River and in the Santee-Cooper system. Dams are contributing to the status of the Carolina DPS by curtailing the extent of available spawning habitat and further modifying the remaining habitat downstream by affecting water quality parameters (such as depth, temperature, velocity, and dissolved oxygen) 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 use 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 either reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality. While many of the threats to the Carolina DPS have been ameliorated or reduced due to existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch and habitat alterations are currently not being addressed through existing mechanisms. Further, despite NMFS's authority under the Federal Power Act to prescribe fish passage and existing controls on some pollution sources, access to habitat and improved water quality continues to be a problem. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the Carolina DPS.

5.2.2.6 South Atlantic DPS of Atlantic sturgeon

The South Atlantic (SA) 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 SA DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the SA DPS and the adjacent portion of the marine range are shown in Figure 11.

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 YOY were observed, or mature adults were present, in freshwater portions of a system (Table 17). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. Historically, both the Broad-Coosawatchie and St. Marys Rivers were documented to have spawning populations at one time; there is also evidence that spawning may have occurred in the St. Johns River or one of its tributaries. Recent evidence shows that a small number of fish have returned to the St. Mary's River, and may use the river for spawning. 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. Fish from the SA DPS likely use other river systems than those listed here for their specific life functions.

Table 17. Major rivers, tributaries, and sounds within the range of the SA DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

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

Secor (2002) estimates that 8,000 adult females were present in South Carolina before the collapse of the fishery in 1890. However, because fish from South Carolina are included in both the Carolina and SA DPSs, it is likely that some of the historical 8,000 fish would be attributed to both the Carolina DPS and SA DPS. The sturgeon fishery had been the third largest fishery in Georgia. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the South Atlantic DPS. We have estimated that there are a minimum of 14,911 SA DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters.

The directed Atlantic sturgeon fishery caused initial severe declines in southeast Atlantic sturgeon populations. Although the directed fishery is closed, bycatch in other commercial fisheries continues to impact the SA DPS. Statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species such as Atlantic sturgeon, but 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 SA DPS, even with existing controls on some pollution sources. Current regulatory regimes are not 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.)

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

Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, this is hampered within the SA 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 SA DPS by modifying spawning, nursery, and foraging habitat. Habitat modifications through reductions in water quality and dissolved oxygen are also contributing to the status of the SA DPS, particularly during times of high water temperatures, which increase the detrimental consequences on Atlantic sturgeon habitat. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch also contributes to the SA DPSs 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 use multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (*e.g.*, exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality. While many of the threats to the SA DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch and habitat alteration are currently not being addressed through existing mechanisms. Further, access to habitat and good water quality continues to be a problem even with NMFS's authority under the Federal Power Act to prescribe fish passage and existing controls on some pollution sources. There is a lack of regulation for some large water withdrawals, which threatens sturgeon habitat. 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 SA DPS.

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

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

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

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

1) Hard bottom substrate (*e.g.,* rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.,* 0.0 to 0.5 parts per thousand (ppt) range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
2) Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g.,sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;
3) Water of appropriate depth and absent physical barriers to passage (*e.g.,* locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:
   - (i) Unimpeded movement of adults to and from spawning sites;
   - (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and
   - (iii) Staging, resting, or holding of subadults or spawning condition adults.

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

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

The paragraphs that follow are excerpted from the ESA Section 4(b)(2) Report for Atlantic sturgeon critical habitat (NMFS (National Marine Fisheries Service) 2017a). That document provides background information on the current status and function of the four critical habitat units designated for the New York Bight DPS, and summarizes their ability to support reproduction, survival, and juvenile development, and recruitment. Additional information on the status of the New York Bight DPS relevant to the current status and function of critical habitat can be found in section 5.2.2.3.

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

The Connecticut River has long been known as a seasonal aggregation area for subadult Atlantic sturgeon, and both historical and contemporary records document presence of Atlantic sturgeon in the river as far upstream as the Holyoke Dam in Hadley, MA (ASSRT 2007, Savoy and Pacileo 2003). The Enfield Dam located along the fall line at Enfield, CT prevented upstream passage of Atlantic sturgeon from 1827 until it was breached in 1977 (ASSRT 2007). The maximum upriver extent of the salt front is to RKM 26. In the spring, high freshwater flow can push the salt front downriver, beyond the river mouth, into Long Island Sound. Tidal influence extends upriver to RKM 90.

In August 2006, an adult-sized Atlantic sturgeon was observed as far upriver as the Holyoke Dam spillway lift at approximately RKM 143 (ASSRT, 2007). However, Atlantic sturgeon are more commonly known to occur further downstream of the Holyoke Dam (Savoy 2007). As noted previously, capture of juvenile (based on size) Atlantic sturgeon in the Connecticut River in 2014, and genetic analysis of tissues collected from the sturgeon strongly suggests spawning is occurring in the river (Savoy *et al.* 2017)[13].

The Hudson River is one of the most studied areas for Atlantic sturgeon. The upstream limit for Atlantic sturgeon on the Hudson River is the Federal Dam at the fall line in Troy, NY, approximately RKM 246 (ASSRT 2007, Dovel and Berggren 1983a, Hilton *et al.* 2016). Recent tracking data indicate Atlantic sturgeon presence at this upstream limit (D. Fox, DESU, pers. comm.). Spawning may occur in multiple sites within the river (Bain *et al.* 2000, Dovel and Berggren 1983b, Kahnle *et al.* 1998, Kynard *et al.* 2016, Van Eenennaam *et al.* 1996). The area around Hyde Park (approximately RKM 134) is considered a likely spawning area based on scientific studies and historical records of the Hudson River sturgeon fishery (Bain *et al.* 2000,

[13] Subsequently, as noted in our SOS section, genetic analysis for 45 of the smallest fish (ranging from 22.5 to 64.0 cm TL) indicated that the sturgeon were most closely related to Atlantic sturgeon belonging to the South Atlantic DPS (Savoy *et al.* 2017). The CT DEEP is conducting a multiyear investigation to further inform the status and origin of Atlantic sturgeon spawning in the river. At this time, we are not able to conclude whether the juvenile sturgeon detected are indicative of sustained spawning in the river or whether they were the result of a single spawning event due to unique straying of the adults from the South Atlantic DPS's spawning rivers.

Dovel and Berggren 1983b, Kahnle *et al.* 1998, Van Eenennaam *et al.* 1996). Habitat conditions at the Hyde Park site are described as freshwater year round with substrate including bedrock, and water depths of 12 to 24 meters (Bain *et al.* 2000). Similar conditions occur at RKM 112, an area of freshwater and water depths of 21 to 27 meters (Bain *et al.* 2000).

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

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

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

> Results of passive acoustic tracking of juveniles less than two years old indicates the area around Marcus Hook is juvenile rearing habitat. Juveniles are repeatedly present and abundant, relative to other areas of the Delaware River where receivers were located. Tracking detections have also shown that areas upriver and downriver of Marcus Hook, from approximately New Castle through Roebling, are frequented by Atlantic sturgeon juveniles, and that juveniles can travel a considerable distance in a short period of time; in excess of 20 RKM within a 24-h period (Calvo *et al.* 2010, Fisher 2011, Hale *et al.* 2016).

> Characteristics of the Housatonic River relative to use by Atlantic sturgeon were described by the ASMFC (1998). The Derby Dam restricts Atlantic sturgeon access to what was likely historical habitat. Nevertheless, the reach of the river from the Derby Dam and downriver to O'Sullivan's Island has strong currents, and a mix of sand, gravel and cobble substrate. The river is tidal from the dam to the mouth of the river, where it discharges into Long Island Sound. The main channel of the river is approximately 5.5 meters deep from the river mouth to RKM 8, and then approximately 2 meters deep as far upriver as the Derby Dam. Atlantic sturgeon less than 100 cm total length (i.e., subadults), are present in the Housatonic River estuary during the summer months. Historical records of an Atlantic sturgeon fishery in the Housatonic River supports the presence of successful spawning (ASMFC 1998, ASSRT 2007), and a likelihood that spawning could still occur in the Housatonic.

The action area for the proposed work considered in this biological opinion covers the Delaware River critical habitat unit from RKM 214 (RM 133) and downstream to RKM 78 (RM 48.5). The critical habitat designation is bank-to-bank within the Delaware River. While the majority of the proposed work in designated critical habitat takes place within the NJWP access channel, turning basin, and berth, indirect effects from turbidity only extends as far as 500 m from a cutterhead dredge. The river is approximately 4,000 m wide at the NJWP site. It also includes the Philadelphia to the Sea and the Philadelphia to Trenton federal navigation channels, RKM 8-133 (RM 5-133). Therefore, the action area overlaps with the majority of the bank-to-bank critical habitat designation in the area described above. Each critical habitat unit contains all four of the physical features (referred to as physical or biological features (PBF)). Information on the PBFs within the action area is contained below in the Environmental Baseline section.

6 ENVIRONMENTAL BASELINE

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

6.1 Environmental Setting

The Delaware River shoreline is generally heavily industrialized. Consequently, the shoreline has lost much of its connection with the floodplain from above Trenton, NJ, to Wilmington, DE. However, larger stretches of the New Jersey shoreline below Little Tinicum Island (RKM 138) consists of relatively undeveloped areas as well as municipal, state, and federal open land and protected tidal marshes. Connection to floodplains provides rivers with nutrients that are important for organic production in riverine ecosystems. Research in the Mississippi River indicates that shovelnose sturgeon and pallid sturgeon early life stages use habitat associated with channel borders such as side channels, areas behind dikes, and island side-channels (Phelps *et al.* 2010, Sechler *et al.* 2012). These areas may provide refuge from strong river flows and predators, as well as provide aquatic insect larva and other small invertebrates for foraging (Phelps *et al.* 2010, Sechler *et al.* 2012). Additionally, Atlantic sturgeon have been observed moving into mudflats during high tide to forage (McLean *et al.* 2013). Thus, the extensive shoreline development with associated hardening of the banks as well as the creation of navigation channels have reduced availability of diverse shoreline habitat. Further, the value of productive foraging areas may decline when natural sedimentation and nutrient processes from upland to deep-river habitat are interrupted by shoreline development. Additionally, hardened surfaces along the shoreline in developed areas increases both runoff and the concentration of pollutants in stormwater.

In contrast, the shorelines downstream of the Delaware to Chesapeake Canal (RKM 94) have long undeveloped stretches, including tidal marshes, on both the Delaware and New Jersey side of the river. The Augustine State Wildlife Management Area (DE) and the Silver Run Wildlife Area (DE) are located directly across from Artificial Island. The downstream shoreline also includes the Cedar Swamp Wildlife Area (DE) and Bombay Hook National Wildlife Refuge (DE). Additionally, the lower Delaware River on the New Jersey side downstream of Pennsville Township (downstream of RKM 105) is less developed with large stretches of undeveloped shoreline. The Supawna Meadows National Wildlife Refuge is located just upstream of Salem River, approximately 11 kilometer (7 miles) upstream of the proposed NJWP site. The Abbotts Meadow Wildlife Management Area is located below Salem River and it includes the area upstream and inland of Artificial Island. The area and shoreline downstream of Artificial Island consists of the Made Horse Creek Wildlife Management Area. Therefore, the lower estuary is generally less polluted and more connected to the floodplain than the areas upstream of New Castle, DE (approximately RKM 104).

6.1.1 Delaware River Flow Management

The Delaware River basin had no major diversions until 1927 when New York City (NYC) built three reservoirs to divert water from the Delaware River Basin to meet the needs of the growing city. A 1954 court order required NYC to release water to maintain a flow rate at Montague, NJ, to compensate for the diverted water and provide water for downstream uses. In 1983, the Delaware River Basin Commission adopted a drought management program and established the Trenton Flow Objective. The Trenton Flow Objective is intended to assure that enough freshwater flows into the estuary to “repel” salinity. Today releases from several basin reservoirs are used to manage freshwater inflows to the estuary.

6.1.2 Water Quality

6.1.2.1 Salinity

Salinity affects the fitness and distribution of sturgeon age classes within the Delaware Bay and the tidal Delaware River. Sturgeon early life stages such as eggs and larvae do not tolerate saline water and their presence is restricted to freshwater reaches upstream of the salt front.

The distribution of salinity in the Delaware estuary exhibits significant variability on both spatial and temporal scales (Figure 12). At any given time, the salinity levels reflect the opposing influences of freshwater inflow from upstream non-tidal portion of the Delaware River, tributaries, and precipitation events versus the saltwater tidal inflow from the Delaware Bay and the Atlantic Ocean, downstream. The estuary can be divided into four longitudinal salinity zones (PDE 2017). Starting at the downstream end, the mouth of the Bay to RKM 44 is considered polyhaline (18-30ppt) with a transition zone between RKM 44-50, RKM 50-92 is mesohaline (5-18ppt) with a transition zone between RKM 92-94, RKM 94-121 is oligohaline (0.5-5ppt), and upstream of RKM 121 is considered fresh (0.0-0.5ppt).

The salt front is considered the freshwater-saltwater interface in the estuary and the location is derived by calculating where the seven-day average chloride concentration equals 250 ppm (parts per million) in the River. Its location fluctuates in response to changing freshwater inflows and with each tidal cycle, but calculations show that current median salt front location range from RKM 107.8 and 122.3 (RM 67-76) (DRBC https://www.nj.gov/drbc/programs/flow/salt-front.html). The Delaware River Basin Commission calculated the 2021 median monthly salt front location between RM 76 (September) and RM 67 (April) just below the Delaware Memorial Bridge (2022). Seasonal and annual differences are much less pronounced today than they were before 1969 when the salt front was further downstream during spring and farther upstream during fall (DRBC 2019). Flow management releases water from upstream reservoirs to augment flows and meet a daily flow target of 3,000 cubic feet per second (84.9 cubic meters per second) in the Delaware River at the Trenton, NJ gage. Therefore, since 1970, low-flow values that once occurred 10% of the time now occur only 1% of the time.

The salt front shifts seasonally with its locations usually being further downstream during spring months and farther upstream during fall months (DRBC 2019). Median locations during the months of April, May, and June (1969 to 2019) are at or below RM 70/RKM 112.7) with the upper 50 percentiles a few miles below RKM 120.7 (RM 75) and the lower 50 percentiles being located at and upstream of RKM 104.6 (RM 65) (DRBC 2019). Median locations during the months of September, October, and November (1969 to 2019) are just upstream of RKM 112.7 (RM 70) with the upper 50 percentiles just below RKM 128.8 (RM 80) and the lower 50 percentiles just above RKM 112.7 (RM 70) (DRBC 2019).

Based on currently known salinity zones and the shifting location of the salt front, sturgeon spawning would have to occur upstream of RM 75/RKM 120.50 with the downstream limit of larvae rearing fluctuating between RM 65/RKM 104 and RM 80/RKM 129. Thus, the action area does not support sturgeon spawning or larval rearing. However, older life stages of Atlantic sturgeon are likely to be present in the action area. A study by Breece *et al.* (2013) demonstrates that adult Atlantic sturgeon are most likely to be within ±30 km of the salt front (2013), which is inclusive of the upper reach of the action area.

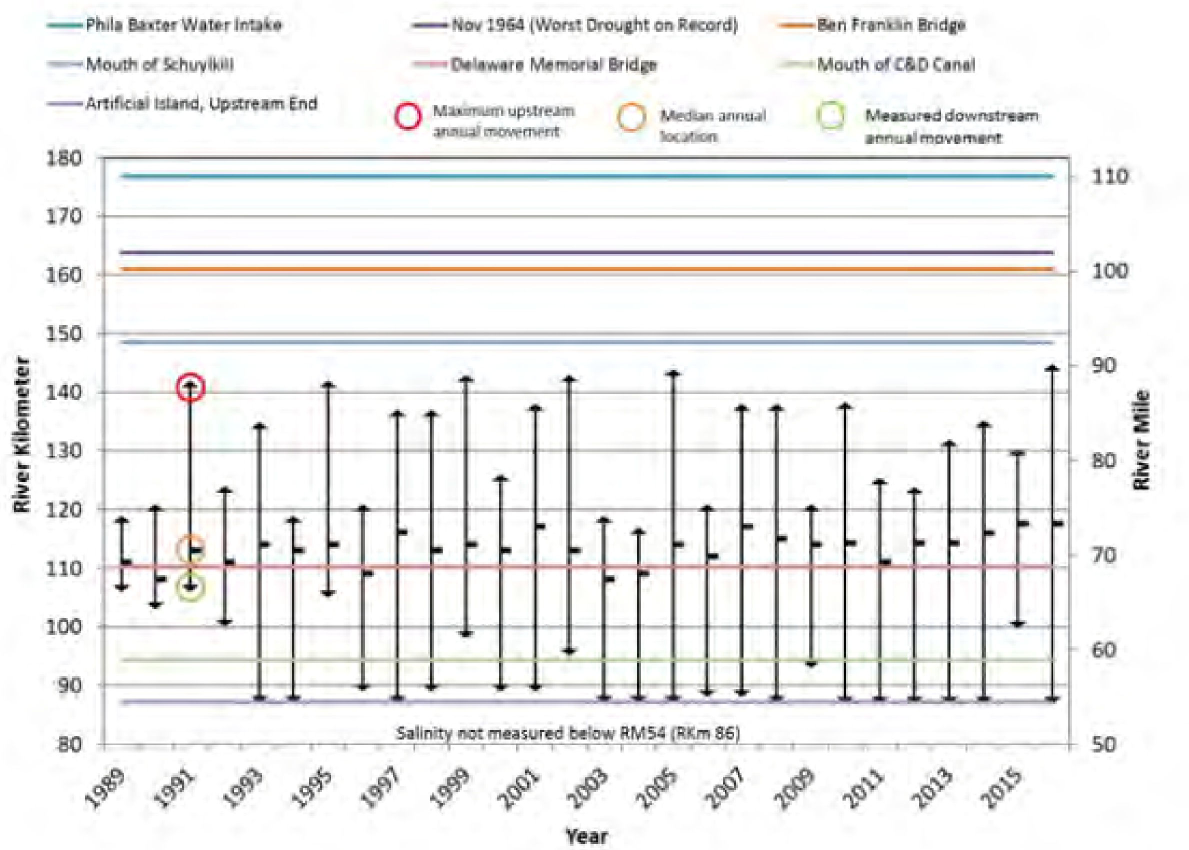

Figure 12. Range of annual salt front locations from 1989-2016. The salt front river mile location is estimated by DRBC using data provided by USGS and the Kimberly Clark Corporation. (Figure 2.5.1. in PDE 2017)

6.1.2.2 Dissolved Oxygen

Dissolved oxygen (DO) refers to the concentration of oxygen gas incorporated in water. Oxygen enters water both by direct absorption from the atmosphere, which is enhanced by turbulence, and as a by-product of photosynthesis from algae and aquatic plants. Sufficient DO is essential to growth and reproduction of aerobic aquatic life; however, low DO levels are connected to elevated nutrient levels (i.e., eutrophication) in the Delaware Estuary and are most likely to occur during summer months. The Delaware Estuary has historically been plagued by hypoxic conditions (severe depression of DO) that results from the discharge of raw and poorly treated wastewater. Although the Estuary has seen a remarkable recovery since the 1960s, with fish such as striped bass and sturgeon now able to spawn more regularly within the Estuary, DO remains a critical issue for the Estuary because of continued depression of oxygen levels below saturation.

USGS continuously measures DO at the Reedy Island gage (USGS 01482800). Dissolved oxygen in the Delaware River near the proposed Port varies greatly based on seasonality, with mean monthly average DO ranging between 13 to 11.4 mg/L in the winter months (i.e., December through January) to between 7 and 6.5 mg/L in the summer months (i.e., June through August) (see Table 18). DRBC's water quality standard for DO in the location of the proposed

Port is a 24-hour average concentration not less than between 4.5 mg/L and 6.0 mg/L in the lower Delaware Estuary. In the most recent Delaware River and Bay Water Quality Assessment (DRBC 2020 https://www.nj.gov/drbc/library/documents/WQAssessmentReport2020.pdf), 96.9% of observations near the Reedy Island gage in the lower Delaware River met daily mean water quality standards criteria and 98.7% of observations in the lower Delaware River and Delaware Bay met the instantaneous minimum criteria.

Table 18. Mean monthly dissolved oxygen calculated from USGS data collected at Reedy Island between 2009 and 2019

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean monthly dissolved oxygen (mg/L)	12.7	13	12	10.1	8.3	7	6.5	6.5	6.9	8.1	10	11.4

There are no available data on DO requirements for Atlantic sturgeon adults and little data for larvae, presenting a gap in the current scientific knowledge, but it is known that juvenile and larval life stage Atlantic sturgeon are sensitive to low DO at both the lethal and sub-lethal levels that occur in the Delaware Estuary. In the Atlantic sturgeon critical habitat designation, it was assumed that 6.0 mg/l DO or greater is needed for juvenile rearing habitat to support growth, development, and recruitment in the New York Bight DPS (Federal Register 2017). There are no reported DO sensitivities for adult shortnose sturgeon, the life stage most likely to be present within the action area. In DO experiments conducted by Jenkins et al. (1993), shortnose sturgeon 22-77 days of age exposed to various DO levels in mostly freshwater at a mean temperature of 22.5°C experienced a significant decrease in percent survival between 3.5 and 3.0 mg/l DO. In addition, using various temperature, DO, and salinity combinations (2.0 to 4.5‰) in 24-hour exposures, Campbell and Goodman (2004) estimated the concentration that kills 50% (LC50) of 77 to 104 day old fish to be 2.7 mg/l (32% DO saturation, 22°C, 4‰), 2.2 mg/l (28% DO saturation, 26°C, 4.5‰), and 3.1 mg/l (42% DO saturation, 30°C, 2‰).

6.2 Listed Species and Critical Habitat in the Action Area

6.2.1 Shortnose Sturgeon in the Action Area

6.2.1.1 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). Based on documented habitat use by various life stages of shortnose sturgeon in the Delaware River, only juveniles and adults of this species are expected to occur in the vicinity of the proposed Port (i.e., eggs and larvae of shortnose sturgeon are not likely to occur there because of high salinity levels).

Although they have been documented in waters with salinities as high as 31 parts per thousand (ppt), shortnose sturgeon are typically concentrated in areas with salinity levels of less than 3 ppt (Dadswell *et al.* 1984). Jenkins *et al.* (1993) demonstrated in lab studies that 76-day old shortnose sturgeon experienced 100 percent mortality in salinity greater than 14 ppt. One-year-old shortnose sturgeon were able to tolerate salinity levels as high as 20 ppt for up to 18 hours but experienced 100 percent mortality at salinity levels of 30 ppt. A salinity of 9 ppt appeared to be a threshold at which significant mortalities began to occur, especially among the youngest fish (Jenkins *et al.* 1993). The Delaware River reach from approximately RKM 50 to 92 (RM 31 to 57.2) is considered mesohaline (5-18ppt) (Section 4.1.2.1).Thus, based on this information and the known salinity tolerances and preferences of shortnose sturgeon, this species is most likely to occur upstream of RKM 91/RM 57 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 50/RM 31. Due to the typical high salinities experienced in the polyhaline zone (below RKM 50/RM 31), shortnose sturgeon are likely to be rare in this reach of the river.

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. Shirey *et al.* (1999) captured nine shortnose sturgeon at Cherry Island Flats and Artificial Island 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, (RKM 102/RM 63.5 – below the Port site) and the Delaware-Pennsylvania line (RKM 126.8/RM 78.3). Shortnose sturgeon have also been documented at the trash racks of the Salem nuclear power plant in Salem, New Jersey at Artificial Island.

The discussion below will summarize the likely seasonal distribution in different reaches of the Delaware River for each shortnose sturgeon life stage. Based on salinity and the best available information on spawning locations, eggs and larvae are not likely to be at the NJWP site. 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 spawning areas is typically triggered in part by water temperature (Bowers-Altman and Brundage 2015). In the Delaware River, movement to the spawning grounds occurs in early spring, usually in late March, with spawning occurring through early May, and sturgeon typically leaving the spawning grounds by the end of May.

Spawning occurs in the upper tidal section and in the riverine reach of the Delaware River upstream of the action area. Studies conducted between 2007 and 2013 (Bowers-Altman and Brundage 2015, ERC 2008) indicate that shortnose sturgeon utilize at least a 22 km reach of the non-tidal river for spawning from Trenton rapids (about RKM 214, RM 133) to the Lambertville rapids.

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 substratequickly after being deposited and will, therefore, remain in the spawning area. Studies of shortnose sturgeon in other rivers have generally found the yolk sac larva (also called free embryo) seek cover in-between coarse bottom substrate particles, and remain near the spawning site (Buckley and Kynard 1981, Kynard and Horgan 2002, Parker 2007). However, some swim up in the water column and drift behavior may occur immediately following hatching if the yolk sack larvae cannot find suitable cover or will undertake this behavior to initiate dispersal(Kynard and Horgan 2002). ERC (2008) sampled both shortnose sturgeon eggs and larvae in D-frame nets set approximately 50 m downstream of the I-95 bridge (approximately RKM 195) in April and May of 2007 and 2008.

We have very little information about shortnose sturgeon post yolk sac larvae distribution in the Delaware River in general. However, larvae do not tolerate saline water. Therefore, if post yolk sac larvae should migrate to the lower estuary, we expect the larvae to nurse above the salt front. The median monthly salt front location range is between RKM 108 and 122, which is upstream of the action area. Based on the information above, shortnose sturgeon early life stages are at least present within the upper portion of the action area but not near the Port site.

Juveniles

Young-of-the-year (YOY) shortnose sturgeon do not tolerate waters with high salinity but concentrate in freshwater upstream of the salt front. Over five winters (2015 to 2020), the USACE conducted blasting of rock outcrops in an effort to deepen the Federal Navigation Channel from 40 ft to 45 ft. Upstream of the action area, blasting of rock formations at Marcus Hook and Tinicum Ranges for the deepening of the Federal Navigation Channel required relocation trawls of sturgeon before blasting occured (e.g., NMFS 2015, 2019). The relocation trawls collected several YOY at the Marcus Hook Range based on their length from December and early January (ERC 2016, 2017, 2018, 2019, 2020b). We do not know when shortnose sturgeon young migrate downstream but the finding of YOY in December indicates that downstream migration from spawning site occur either as drifting post yolk sac larvae or in fall after they are fully developed into juveniles.

A total of 1,356 shortnose sturgeon were captured during the five seasons of relocation trawling. Juveniles (<500 mm Fork Length) represented from 9% of 539 total (2017-2018 relocation) to 92.3 percent of 259 (2019-2020 relocation). The results from the relocation trawls carried out each winter from 2015-2016 to 2019-2020, indicate that juvenile shortnose sturgeon are present in the Marcus Hook area during the winter in larger numbers than previously predicted.

In other river systems, older juveniles (3-10 years old) occur in the saltwater/freshwater interface and may move downstream into waters with moderate salinity (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 (DRBC 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).

Early telemetry studies found that large juvenile shortnose sturgeon (length ranged from 454-566 mm TL) use the lower estuary during early late fall with the largest sturgeon spending most of its time in the Baker Range (i.e., the Port Site) during late fall to January (ERC 2007). Further, the BA for this consultation and (ERC 2020a) provide the results of tracking studies that indicate that during the winter months juvenile shortnose sturgeon are more widely distributed in the Delaware River and likely within the action area than previously thought. Juvenile (225 to 490 mm FL) and adult (502 to 905 mm FL) shortnose sturgeon were acoustically tagged as part of the sturgeon protection and monitoring program associated with USACE's Delaware River deepening project (ERC 2020a). Based on telemetry data collected on acoustic receivers in the vicinity of Artificial Island (Figure 13), juvenile shortnose sturgeon were detected in greatest abundance in the spring (i.e., April through June) and fall (i.e., October through December) and were detected in lowest abundance or not detected during January through February or July through September (Figure 14). Only 29% of tagged juveniles were detected in the vicinity of the Project Area. As with juvenile and subadult Atlantic sturgeon, telemetry data indicate that juvenile shortnose sturgeon are more commonly observed upstream of the proposed Port only making seasonal excursions downriver to the reach adjacent to the proposed Port in the action area (Figure 15).

Figure 13. Locations of acoustic receivers in the vicinity of Artificial Island

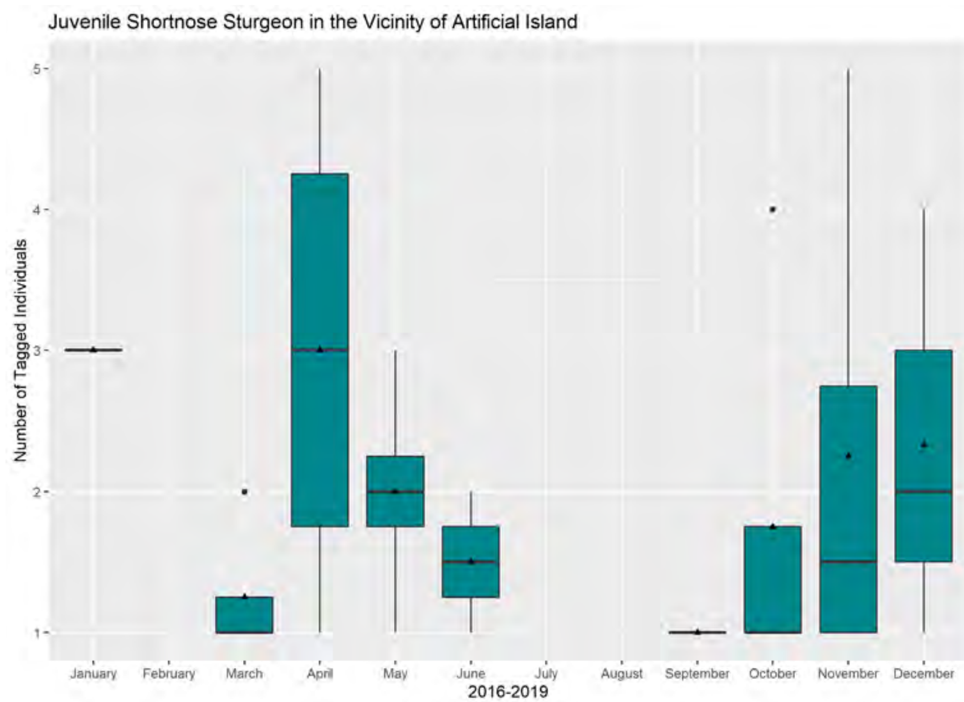

Figure 14. Number of juvenile shortnose sturgeon detected in the vicinity of Artificial Island (graphic from BA)

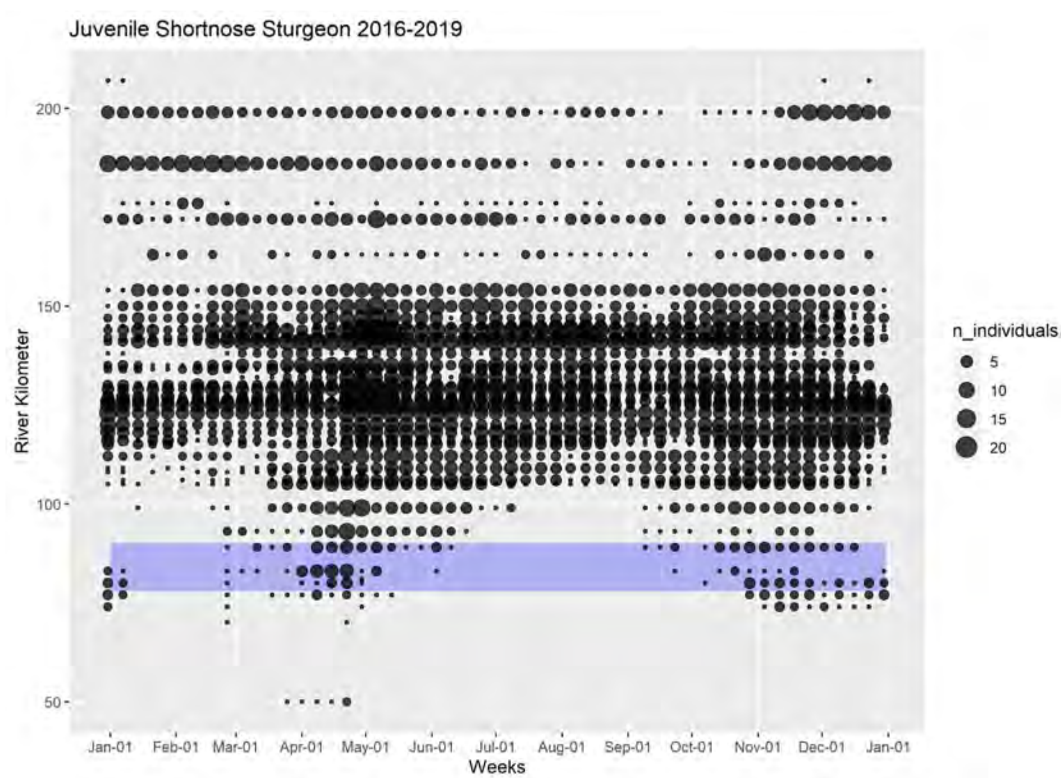

Figure 15. Spatial distribution of juvenile shortnose sturgeon in the Estuary. The purple shading shows the reach of the River in the vicinity of Artificial Island (graphic from BA)

Adults

After spawning, which occurs during spring months and ceases by the time water temperatures reach 15ºC (although sturgeon have been reported on the spawning grounds with water temperatures as high as 18ºC), shortnose sturgeon move rapidly downstream to the Philadelphia area (~RKM 161). After adult sturgeon migrate to the area around Philadelphia, many adults return upriver to between RKM 204 and 216 within a few weeks, while others gradually move to the same area over the course of the summer (O'Herron *et al.* 1993). However, the capture of multiple shortnose sturgeon at the Cherry Island Flats at RKM 119 (RM 74) during the summer months (Shirey *et al.* 1999) indicates that shortnose sturgeon are likely to be foraging in the lower estuary and at Artificial Island. This area may serve as a summer aggregation site.

By the time water temperatures have reached 10°C, typically by mid-November[14], 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 upstream overwintering grounds between RKM 190 and 211 between early November and mid-April.

Early studies of shortnose sturgeon adult movements found that some of the tagged adults moved rapidly between the upper tidal river (RKM 212/RM132) and the lower tidal river, moving as far downstream as RKM 93 (RM 58). These movements occurred in spring and early to mid-winter and were likely associated with sturgeon moving downstream to summer foraging and upstream to overwintering areas, respectively (ERC 2006a). However, three fish overwintered below Wilmington DE, but Aberdeen (1994) concluded that the majority of individuals overwinter in upstream areas below Trenton, NJ (RKM 212/RM 132).

Newer data indicates that adult shortnose sturgeon are present in the Marcus Hook area during the winter in larger numbers than previously predicted. The relocation trawls during deepening blasting within the Marcus Hook, Chester, Eddystone, and Tinicum ranges of the channel during the winters from 2015-2016 to 2019-2020 collected a large number of adult shortnose sturgeon. These data further demonstrate the use of the lower tidal river (below Little Tinicum Island) 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 widely 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

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[14] 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).

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.

Shortnose sturgeon have been encountered at the cooling water intake at Salem Generating Station, immediately downriver of the proposed Port (NMFS consultation with PS&G 2021). From 2010 to 2019, this species was collected at Salem's cooling water intake in almost all months of the year (Table 19), but in lower numbers than Atlantic sturgeon (BA). Shortnose sturgeon were most frequently encountered at the station in December and March. All of the shortnose sturgeon that were classified by life stage based on length (i.e., 87% of shortnose sturgeon encountered) were adults.

Table 19 – Shortnose Sturgeon Collected at Salem Generating Station from 2010 to 2019 (table 8 in the biological assessment for this project)

Month	Adult	Unknown[2]	Total Number Encountered
January	1	1	2
February	2	1	3
March	3	0	3
April	1	0	1
May	2	0	2
June	0	0	0
July	1	0	1
August	0	0	0
September	1	0	1
October	0	1	1
November	2	0	2
December	4	0	4

[1]Total length of sturgeon was used to assign life stage based on life history information in NMFS 2018b.
[2]Total length was not available for all Atlantic sturgeon encountered at Salem Generating Station.

Telemetry data for adult shortnose sturgeon indicate that adults display similar seasonality as juveniles (ERC 2020a). Adults are most abundant in the vicinity of Artificial Island during April, May, and to some extent June and occur at lower abundance from October through December (Figure 16). Adult shortnose sturgeon are least abundant or not present from July through September and January through March. Fifty-seven percent of tagged adult shortnose sturgeon were acoustically detected in the vicinity of Artificial Island. As was the case for juveniles, the distribution of adult shortnose sturgeon is concentrated upriver of the Project Area, though their distribution exhibits seasonal shifts downstream (Figure 17).

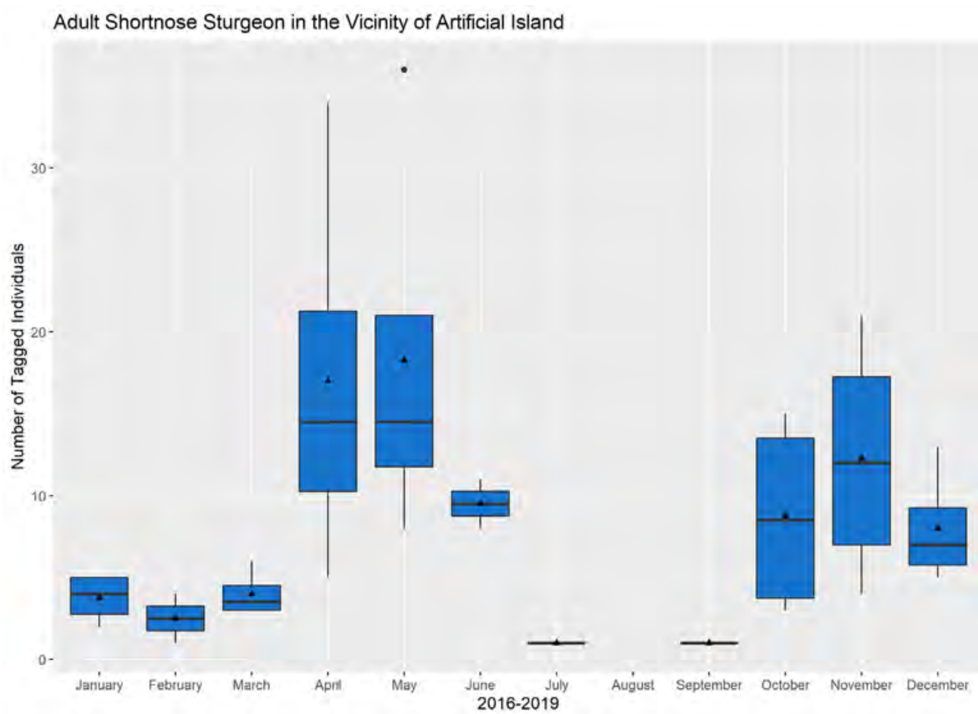

Figure 16. Number of adult shortnose sturgeon detected in the vicinity of Artificial Island (Source: Figure 16 in BA)

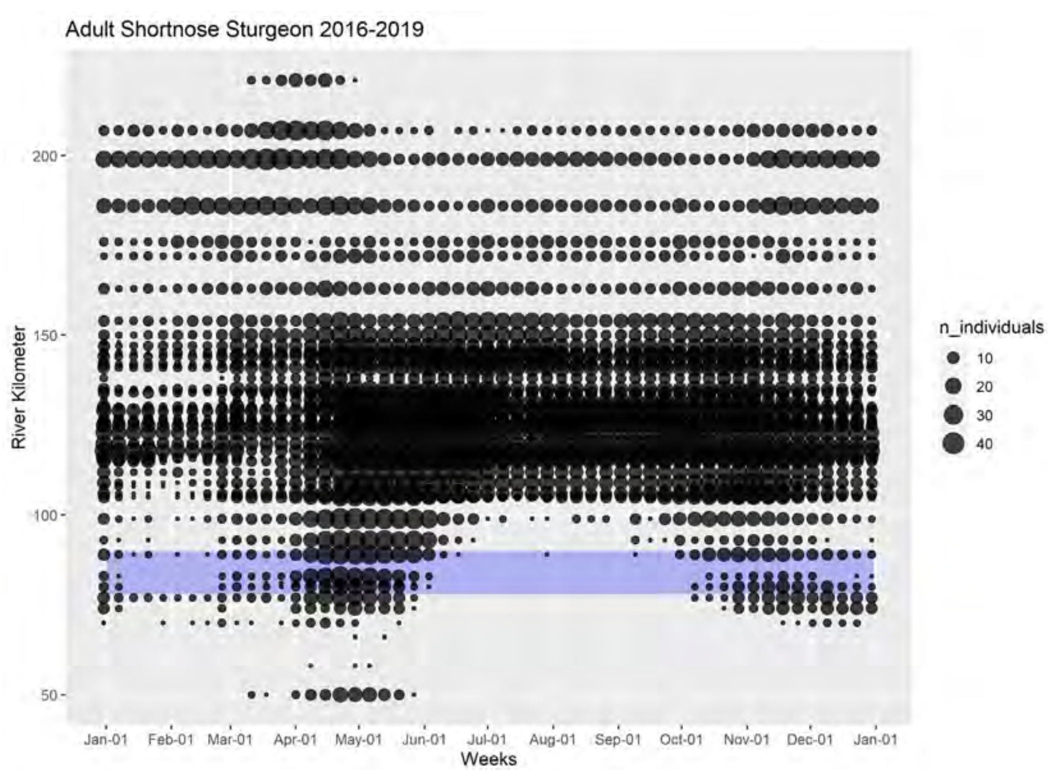

Figure 17. Number of adult shortnose sturgeon detected in the vicinity of Artificial Island (Source: Appendix A)

6.2.1.2 Summary of Shortnose Sturgeon Presence in the Action Area

The discussion below summarizes the likely seasonal distribution of shortnose sturgeon in river reaches within and just upstream of the action area. Based on salinity and the best available information on spawning locations, eggs and larvae are not likely to be present within these reaches. The results of tracking studies and relocation trawling indicate that during the winter months, juvenile and adult shortnose sturgeon are more widely distributed in the lower Delaware River than previously thought. Distribution of adult and juvenile shortnose sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity.

Little Tinicum Island to Trenton, NJ – Tidal Freshwater: Reach from RKM 138 to 214 (RM 86 to 133). Spawning occurs in riverine reaches upstream of Trenton, NJ, and potentially in the upper tidal river. Eggs and larvae are likely to occur in the upper tidal river and potentially downstream to Philadelphia, PA. Young shortnose sturgeon occur throughout the reach and use the channel for downstream migration to rearing areas at Marcus Hook. Adult shortnose sturgeon overwinter in dense aggregations in the upper tidal river between around Duck Island and Newbold Island. Adults use the channel to migrate downstream after spawning to reside in areas at and downstream of Philadelphia.

Claymont, DE, to Little Tinicum Island – Tidal Freshwater: Reach from RKM 120.5 to 138 (RM 57 to 86). This reach includes the Marcus Hook Range where a large number of shortnose sturgeon juveniles, including YOY, are present indicating that this part of the river is an important year round rearing area. Adult shortnose sturgeon are present in this section of the river during winter.

Elsinboro Point, NJ, to Claymont, DE – Transition and Oligohaline: Reach from RKM 92-120.5 (RM 57-75). This reach includes the New Castle and Cherry Island Range where the 2003-2004 telemetry studies indicated was an area frequented by shortnose sturgeon. This area also includes the outlet of the Chesapeake-Delaware canal which has been documented to be used by shortnose sturgeon moving between the upper Chesapeake Bay and the Delaware River. Based on the best available information, adult and juvenile shortnose may be present in this reach of the river year round in larger numbers than was previously considered.

Port Site Reach - Mesohaline: Lower estuary, RKM 78-92 (RM 48.5-57), and includes the area near Artificial Island. Both juvenile and adult shortnose sturgeon are present from the upstream end of the Artificial Island to the mouth of the river with the Delaware Bay. However, the low number of juveniles documented occurrences in this reach combined with the higher salinity levels, make this reach less likely to be used by juveniles than other upstream reaches. Best available information indicates that the highest concentration of both adults and juveniles adjacent to and within the Project Area occur from April to June and October to January. Shortnose sturgeon may be absent from this reach or occur in very low numbers during July through September.

Vessel Transit Route: Downstream of RKM 78/RM 48.5, i.e. the Delaware Bay. As tolerance to salinity increases with age and size, occasional Adult and late-stage juvenile shortnose sturgeon may occur through the mesohaline area extending to RKM 50 between late April and mid-November. Due to the typical high salinities experienced in the polyhaline zone (below RKM 50), shortnose sturgeon are likely to be rare in the Delaware Bay.

6.2.2 Atlantic Sturgeon in the Action Area

6.2.2.1 Overall distribution of Atlantic sturgeon within the Delaware River and Bay

In the Delaware River and Estuary, Atlantic sturgeon occur from the mouth of the Delaware Bay to the fall line near Trenton, NJ, a distance of almost 220 km (Hilton *et al.* 2016, Simpson 2008). All historical Atlantic sturgeon habitats appear to be accessible in the Delaware (ASSRT 2007); however, given upstream shifts in the salt wedge over time, less river miles of freshwater habitat are available to Atlantic sturgeon compared to pre-industrial times.

Spawning

Spawning may occur from April to July. Atlantic sturgeon early life stages do not tolerate saline waters. Thus spawning must occur in freshwater upstream of saltwater intrusion. Based on this, spawning does not occur within the action area.

Cobb (1899) and Borodin (1925) reported spawning between RKM 77 and 130 (Delaware City, DE to Chester City, PA). However, based on tagging and tracking studies, current 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 upstream shift from historical spawning sites is thought to be at least partially a result of dredging and climate change that shifted the location of the salt wedge over time and likely eliminated historic spawning habitats in the lower Delaware River (Breece *et al.* 2013). Though only one larva has been collected from the river, as noted below, the recent documented presence of YOY in the Delaware River provides confirmation that regular spawning is still occurring in this river.

The likely spawning area in the lower tidal river closest to the NJWP site is located between the Marcus Hook Bar (RKM 125) and the downstream end of Little Tinicum Island (RKM 138). This area has hard bottom habitat believed to be appropriate for sturgeon spawning (gravel/coarse grain depositional material and cobble/boulder habitat) (Breece *et al.* 2013, Sommerfield and Madsen 2003). Tracking of adult male and female Atlantic sturgeon confirmed the use and affinity to this area by adults during April to July (Breece *et al.* 2013). The sturgeon selected areas with mixed gravel and mud substrate (Breece *et al.* 2013), DiJohnson *et al.* (2015). At last, a yolk sac larva was entrained in the cooling intake of the Eddystone Generating Station in 2017 (NMFS 2020). The presence of yolk sac larvae confirms that spawning occur in this reach of the river.

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.

Early Life Stages

All early life stages are intolerant of high salinity and only occur in the freshwater reach of the river. Therefore, early life stages will not occur at the Port or in the reach immediately upstream of Artificial Island.

Atlantic sturgeon eggs are adhesive and stick to the substrate. Therefore, eggs will remain at or near the site where the female releases her eggs in appropriate spawning habitat. Based on studies in artificial streams, hatchlings (yolk-sac larvae) will seek cover in the interstitial spaces of larger material such as gravel and cobble and are assumed to inhabit the same riverine or estuarine areas where they were spawned (Bain *et al.* 2000, Kynard and Horgan 2002). There is no information about post yolk sac larvae (stage when the larva has exhausted the yolk sac and is free moving) distribution and presence in the Delaware River. However, post yolk sac larvae are believed to drift with currents downstream to areas immediately above the salt front where they settle to feed and grow (Kynard and Horgan 2002). Based on the suspected spawning location within the Marcus Hook and Eddystone Ranges as well as what is known about post yolk sac larvae, early life stages may occur upstream of the median monthly lower salt front location at RKM 108/RM 67. Therefore, Atlantic sturgeon early life stages, such as eggs and larvae are not present in the river near Artificial Island where the NJWP will be located.

Juveniles

All juvenile (non-migratory) Atlantic sturgeon are part of the New York Bight DPS. Juvenile Atlantic sturgeon are present from the mouth of the Delaware River and upstream to Trenton, NJ. Within the lower estuary, juveniles are present in the river off Artificial Island year round but with higher concentrations during spring/early summer and late fall. Older juveniles may move into the Delaware Bay and eventually make their way to marine waters at two-years or older.

YOY Atlantic sturgeon nurse in the Delaware River below Little Tinicum Island to just upstream of the salt front. Sampling in 2009 targeted YOY and resulted in the capture of more than 60 YOY in the Marcus Hook anchorage (RKM 127) area during late October through late November 2009 (Calvo *et al.* 2010, Fisher 2009). Two telemetry studies of YOY with acoustic tags showed that YOY use several areas from Deepwater (RKM 105) to Roebling (RKM 199) during late fall to early spring. Some remained in the Marcus Hook area while others moved upstream, exhibiting migrations in and out of the area during winter months (Calvo *et al.* 2010, Fisher 2011). At least one YOY spent some time downstream of Marcus Hook (Calvo *et al.* 2010, Fisher 2011). Downstream detections from May to August between Philadelphia (RKM 150) and New Castle (RKM 100) suggest non-use of the upriver locations during the summer months (Fisher 2011). Based on this and the fact that YOY have low tolerance to saline waters, it is unlikely that YOY occur within the action area.

Salinity intrusion and water temperatures seems to influence summer distribution of late stage juveniles in the river with concentrations in the Marcus Hook occurring during years with high salinity and water temperatures and expanded distribution downstream to and below Artificial Island during years with below average salinity and water temperature (Fisher 2011). During the summer months, concentrations of Atlantic sturgeon have been located in the Marcus Hook

(RKM 123-129) and Cherry Island Flats (RKM 112-118) regions of the river (Simpson, 2008; Calvo *et al.*, 2010) as well as near Artificial Island (Simpson 2008). Brundage et al. (2014), found that the juveniles shifted their center of distribution progressively down-estuary as they aged, until they migrated to the higher salinity waters of Delaware Bay and eventually the nearshore Atlantic Ocean during the fall of their second or third years. Brundage and O'Herron (in Calvo *et al.* (2010)) tagged 26 juvenile Atlantic sturgeon, including six young of the year (YOY). For one-year old juveniles and older, 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).

Atlantic sturgeon area encountered at Salem Generating Station's cooling water intake, immediately downriver from the proposed Port (NMFS 2014). From 2011 through 2019,[15] Atlantic sturgeon have been collected at Salem's cooling water intake in all months of the year, except July (Table 20). Sturgeon were most frequently encountered at the intake between December and April. Of the Atlantic sturgeon that could be assigned to a life stage based on total length, a majority (73%) were juveniles.

Table 20. Atlantic Sturgeon Collected at Salem Generating Station from 2011 through 2019 (Source: Table 7 in the BA)

Month	Life Stage[1]					Total Number Encountered
	Young of the Year	Juvenile	Subadult	Adult	Unknown[2]	
January	0	9	0	0	1	10
February	0	8	3	1	1	13
March	0	8	3	0	5	16
April	0	8	5	0	4	17
May	0	1	1	0	2	4
June	0	0	0	0	1	1
July	0	0	0	0	0	0
August	0	0	2	0	0	2
September	1	0	0	0	0	1
October	0	1	0	0	1	2
November	0	5	0	0	4	9
December	0	16	3	1	2	22

[1]Total length of sturgeon was used to assign life stage based on life history information in NMFS 2018b.
[2]Total length was not available for all Atlantic sturgeon encountered at Salem Generating Station

Juvenile Atlantic sturgeon (254 to 750 mm fork length) were acoustically tagged from 2015 to 2019 as part of a sturgeon protection and monitoring program associated with the USACE

[15] PSEG did not begin documenting Atlantic sturgeon encounters at Salem Generating Station until this species was proposed for listing under the Endangered Species Act in February 2011.

Delaware River deepening project. Telemetry data from 2016 to 2019 indicate that acoustic-tagged juvenile Atlantic sturgeon occur in the vicinity of Project area throughout the year, based on acoustic detections at receivers in the vicinity of Artificial Island (Figure 13). However, their utilization of the area varied seasonally. Detections of juvenile Atlantic sturgeon were relatively low between December and March. The greatest number of juvenile sturgeon were detected between April and June and in October and November (Figure 18). Although fewer Atlantic sturgeon were detected in the vicinity of Artificial Island during the summer, the residence time for those that were detected was highest in July and August. Of the 287 acoustic-tagged Atlantic sturgeon at large in the River, approximately 60% were detected in the vicinity of Artificial Island at some point during the monitoring. However, the telemetry data also show that juvenile Atlantic sturgeon are more commonly detected upriver of the Port site. In general, within the Delaware River, the distribution of juvenile Atlantic sturgeon is centered on the Marcus Hook-Chester ranges (RKM 121-136) (Figure 19), consistent with earlier acoustic tracking studies (Brundage and O'Herron, 2009; Brundage et al., 2014; Hale et al., 2016).

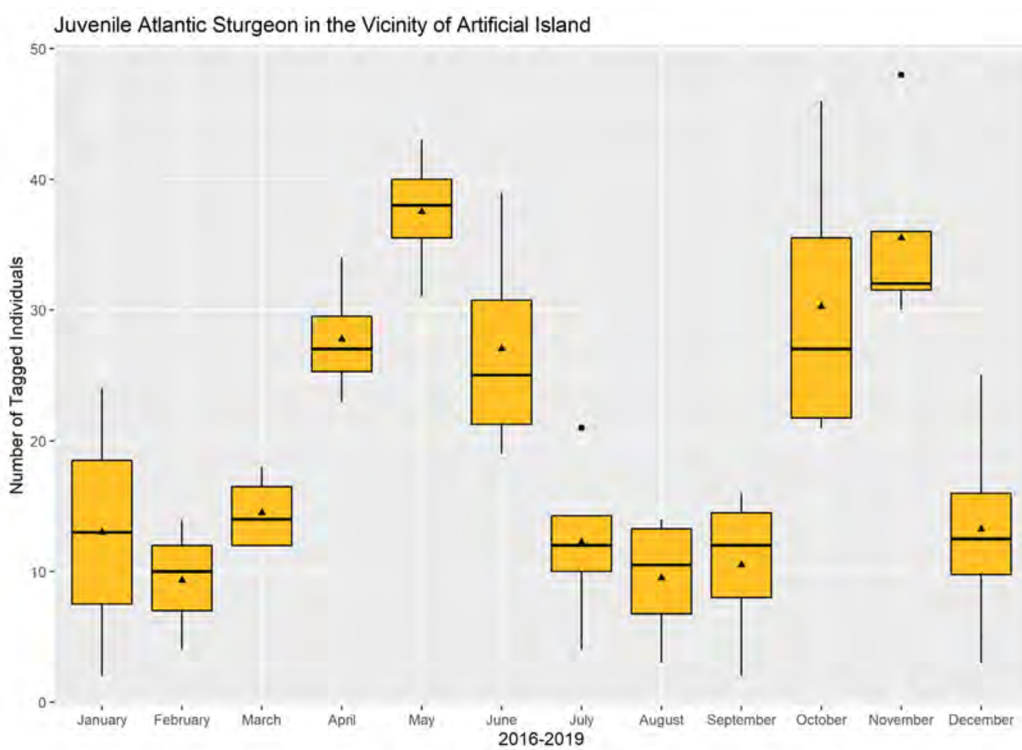

Figure 18. Number of juvenile Atlantic sturgeon detected in the vicinity of Artificial Island (Source: Figure 12 in BA)

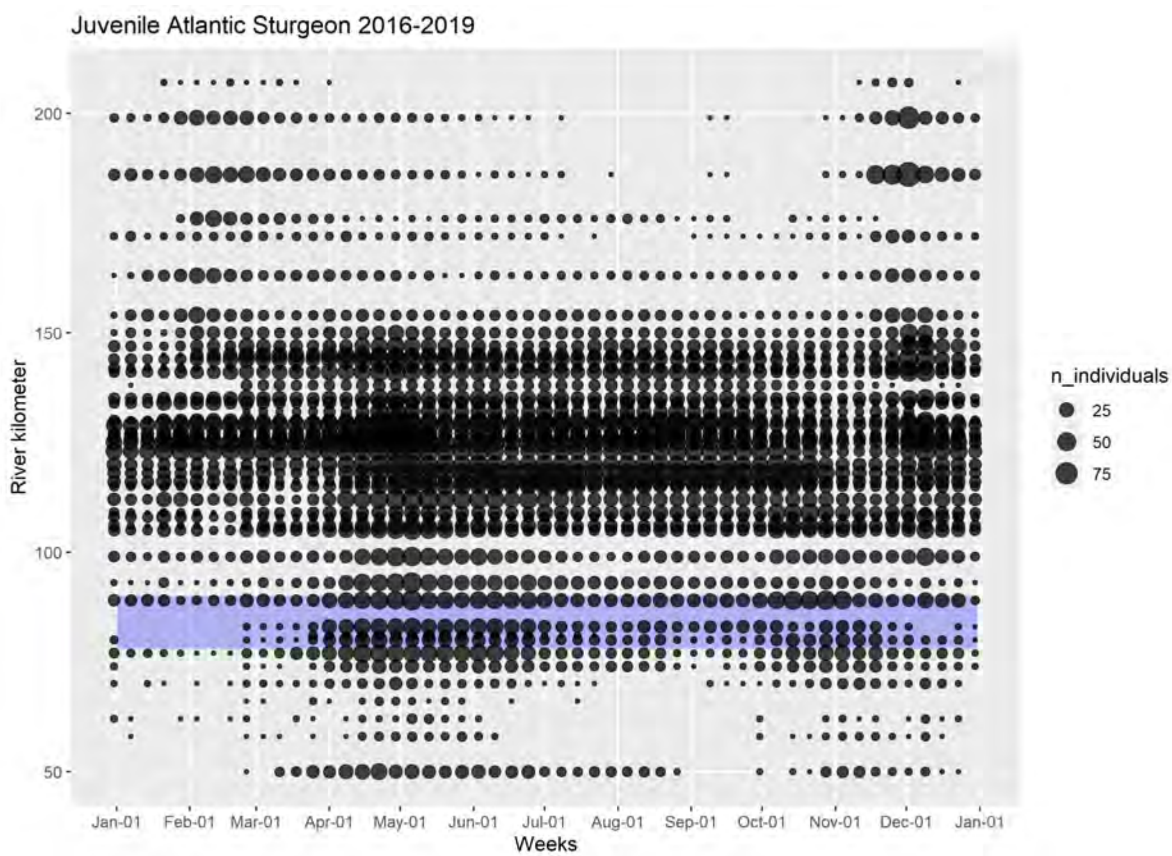

Figure 19. Spatial distribution of juvenile Atlantic sturgeon in the Estuary based on acoustic telemetry monitoring conducted from 2016 through 2019. Purple shading shows the reach of the River in the vicinity of Artificial Island (Source: Figure 13 in BA)

Adults and Subadults

Adult and subadult (non-natal late stage juveniles) Atlantic sturgeon both move through the action area during up and downstream migrations as well as for foraging and spawning staging (NYB adults only). Adults and, especially, subadults occur and reside in lower estuary where the proposed port will be located while both life stages occur in dense aggregations throughout Delaware Bay and at the mouth of the Delaware Bay. The majority of adults entering the river are of Delaware River origin while subadults may belong to any DPS. Adult and subadult Atlantic sturgeon in the Delaware Bay and at the mouth of the Bay consists of a mixture of several DPSs.

Spawning adults migrate upstream through the action area adjacent to the proposed Port site during April and May. Spawning occurs through mid- to late-June (Simpson 2008). Females leave the spawning sites to move downstream soon after spawning but males may remain in the river until October. Some research indicates 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). However, at this time, more research is needed to confirm whether or not an independent run of fall spawning Atlantic sturgeon is occurring in the Delaware River.

The Delaware River estuary (the lower tidal river) and Bay are used by sturgeon from multiple DPSs. Genetic studies, however, show that the majority of sturgeon are assigned to the Delaware River population (Kazyak *et al.* 2021). Generally, 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 coastal areas in the fall-winter (Brundage and Meadows, 1982; Lazzari *et al.*, 1986; Shirey *et al.*, 1997; 1999; Brundage and O'Herron, 2009; Brundage and O'Herron in Calvo *et al.*, 2010).

Fox *et al.* (2015) tracked (2009-2014) adult Atlantic sturgeon captured in marine waters off the Delaware Bay in the spring in an attempt to locate spawning areas in the Delaware River. Adults mostly used the area from New Castle, DE (RKM 100) to Little Tinicum Island (RKM 138) though adult Atlantic sturgeon were detected as far upstream as Roebling, NJ (RKM 201) (Fox *et al.* 2015). The earliest detection was in mid-April while the latest departure occurred in mid-June; supporting the assumption that adults are only present in the river during spawning. However, Fox *et al.* (2015) also observed several individuals of both sexes and unknowns that entered the river later in the spring and occupied suitable spawning habitats into the fall months. The sturgeon spent relatively little time in the river each year, generally about four weeks, though adult sturgeon of unknown sex remained in the area of likely spawning twice as long (67.1 days).

In general, Atlantic sturgeon from all rivers move south along the Atlantic coast during winter and north during summer (Erickson et al. 2011, Hilton et al. 2016, Smith 1985). Aggregations of sturgeon from Long Island to Virginia during winter months indicate the presence of important overwintering areas in coastal waters (Dunton et al. 2010). Aggregation areas are usually associated with bay mouths and inlets. The Delaware Bay mouth has been identified as a aggregation area (Dunton *et al.* 2010, Erickson *et al.* 2011, Fox *et al.* 2010, Stein *et al.* 2004b). Off the coast of New Jersey, Atlantic sturgeon generally uses depths between ten and 50 m and most captures occurs at depths of 20 m or less (Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011). Savoy and Pacileo (2003)found that Atlantic sturgeon occur at depths as shallow as 2.5 m (8.2 ft).

A number of recent studies have provided us with an increasing understanding of Atlantic sturgeon utilization of the Delaware Bay and nearshore areas near its mouth (Breece *et al.* 2016, Breece *et al.* 2017, Breece *et al.* 2018, Haulsee *et al.* 2020, Kuntz 2021). These studies have identified important aggregations of Atlantic sturgeon subadults in the lower Delaware Bay and in the Atlantic Ocean off the Delaware Bay. Most of these aggregations occur adjacent to or within established shipping lanes (Breece *et al.* 2018, Haulsee *et al.* 2020). While Atlantic sturgeon may be present year round in these areas, both density and residency varies seasonally among sites. Depth distribution also shifts with season as fish inhabit the deepest waters during winter and shallowest waters during summer and early fall. High occurrence rates at the mouth of the Delaware Bay occur in April and June and again in September and October corresponding with seasonal migration into and out of the Delaware Bay, respectively (Breece *et al.* 2017, Haulsee *et al.* 2020). The highest number of Atlantic sturgeon within the Delaware Bay occur during late spring through the fall while the highest number of Atlantic sturgeon in the deeper waters off the mouth occur during November and December. (Fox and Breece 2010) detected a large aggregation of telemetered adult and subadult Atlantic sturgeon near the mouth of the Delaware Bay during summer months. During winter, Atlantic sturgeon movement level is high with small pockets of resident fish in deeper water near the mouth of the Delaware Bay occurring in early spring (Breece *et al.* 2018). As temperature increases, pockets of resident Atlantic sturgeon expand in an isolated region near the mouth of the Delaware Bay. Kuntz (2021)also found a large number of Atlantic sturgeon concentrated from late spring through the fall in two locations in the lower Delaware Bay. Telemetry studies and modeling identified Atlantic sturgeon areas of residency on the eastern side of the Delaware Bay and possibly in the shallow waters on the southwest side of the Delaware Bay (Breece *et al.* 2018). These areas are where many individuals remain from May to October. Breece *et al.* (2018)postulated that upwelling brings in cooler, nutrient-rich, highly oxygenated offshore waters that provide near-optimal metabolic temperatures along the bottom. Environmental conditions have also led to ideal foraging opportunities for Atlantic sturgeon and examination of gut content has confirmed that Atlantic sturgeon are feeding on benthic invertebrates in these areas (Fox and Madsen 2020).

6.2.2.2 Summary of Atlantic Sturgeon Presence in the Action Area

The discussion below summarizes the likely seasonal distribution of Atlantic sturgeon in river reaches within and just upstream of the action area. Atlantic sturgeon are well distributed throughout the Delaware River and Bay and could be present year round in the action area. Based on salinity and the best available information on spawning locations, eggs and larvae are not likely to be present within these reaches. Juvenile, subadult, and adult Atlantic sturgeon are present throughout the action area. Adults and subadults may also be present in the navigation channel and pilot area off the Delaware Bay mouth. Distribution of adult and juvenile Atlantic sturgeon in the action area is influenced by seasonal water temperature, the distribution of forage items, and salinity.

Little Tinicum Island to Trenton, NJ – Tidal Freshwater: Reach from RKM 138 to 214 (RM 86 to 133). Adult Atlantic sturgeon have been tracked as far upstream as the fall line by Trenton, NJ, during spring and into July. Spawning may occur throughout this reach where suitable spawning substrate is present. Thus, early life stages may be present from May through August. Juveniles occur in the river year round.

Claymont, DE, to Little Tinicum Island – Tidal Freshwater: Reach from RKM 120.5 to 138 (RM 57 to 86). This reach includes the Marcus Hook Range to the Little Tinicum Ranges and is an important nursing area for juveniles, with the Marcus Hook Range supporting high densities of YOY and young juveniles. The reach also includes likely Atlantic sturgeon spawning sites along the edge of the navigation channel. Post yolk sac larvae may occur throughout the reach above the salt front from late May to September depending on when spawning occurs.

Elsinboro Point, NJ, to Claymont, DE – Transition and Oligohaline: Reach from RKM 92-120.5 (RM 57-75). This includes the New Castle range where the outlet of the Chesapeake-Delaware canal is located, and which Atlantic sturgeon may use to move between the upper Chesapeake Bay and the Delaware River. Early life stages and young juveniles are unlikely to be present because of the unsuitable levels of higher salinity. Older Atlantic sturgeon juveniles expand their distribution into this reach as they become increasingly tolerant to saline waters with age but their center of distribution depends on salinity and water temperature. Adults use the channel for spawning migration from April through July.

Port Site Reach - Mesohaline: Lower estuary, RKM 78-92 (RM 48.5-57), and includes the river channel at Artificial Island. Early life stages and young juveniles will not be present due to unsuitable salinity levels in this reach. Older (age-1+) juvenile, subadult, and adult Atlantic sturgeon are present from the upstream end of the Artificial Island to the mouth of the river with the Delaware Bay. Best available information indicates that the highest concentration of juveniles adjacent to and within the Project Area occur from April to June and October to December. Adults start moving into the river in April to migrate to spawning sites. Adult and subadult summer and fall aggregation areas occur at the mouth or the river.

Delaware Bay: The Philadelphia to the Bay navigation channel from RKM 78 to 5, the pilot boarding area, and regulated Precautionary Area offshore of the mouth of the Bay. The Delaware Bay is polyhaline (> 18 ppt salinity). Adult and subadult Atlantic sturgeon move through the bay in April and June and again in October to December corresponding with spawning and coastal migration patterns, respectively. Adults and subadults aggregations at the mouth of the Delaware Bay occur from April to November. However, adults and subadults are present year round but with lower occurrences during winter months. Migrating adults belong to the New York Bight DPS, but subadults and non-mature adults may belong to multiple DPSs.

6.2.3 Delaware River Critical Habitat Unit

As noted in section 4.0, the action area considered in this biological opinion includes the navigation channel from the mouth of the Bay (RKM 0) to RKM 214 (RM 133) and the Port site. The Delaware River critical habitat unit is the Delaware River extending from the crossing of the Trenton-Morrisville Route 1 Toll Bridge (approximately RKM 114/RM 133) downstream to where the river discharges into Delaware Bay at RKM 78 (RM 48.5). Thus, the action area overlaps with all critical habitat within the Delaware River. The action area contains all four PBFs.

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

Physical and Biological Feature 1

Hard bottom substrate in low salinity waters suitable for the settlement of fertilized eggs, refuge, growth, and development of early life stages (i.e., PBF 1) are present in the reaches of the river upstream of Artificial Island. DRBC (2017) identifies RKM 107.8 as the lower part of the median range for the salt front (defined as 0.25 ppt); the historic salt front location is reported as approximately RKM 92. PDE (2017) defined the oligohaline zone (i.e., the area that on average has salinity of 0.5 ppt or less) as the river between RKM 71 and 127 is oligohaline (0.5-5ppt). However, 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 2009). Given the dynamic nature of salinity near the salt front, the availability of data on salinity levels of 0.25 ppt and not 0.5 ppt and the very small area where there would be a difference in salinity between 0.25 and 0.5 ppt, it is reasonable to use the furthest downstream extent of the median range of the location of the salt front (0.25 ppt) as a proxy for the downstream border of PBF 1 in the Delaware River. Therefore, we consider the area upstream of RKM 107.8 to have salinity levels consistent with the requirements of PBF 1. This stretch of river with the required attributes above RKM 107.8 is upstream of the action area.

Physical and Biological Feature 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 can be found within the action area. Therefore, PBF 2 is present within the action area.

There is no clear salinity gradient within the Delaware River estuary. However, the river from RKM 93.9 to RKM 120.54 (RM 58.4 to RM 74.9) is characterized as ologohaline (0.5 to 5 ppt) and from RKM 49.8 to RKM 91.9 (RM 30.9 to RM 57.1) as mesohaline (5 to 18 ppt). A salinity transition zone occurs from RKM 91.9 to RKM 93.9 (RM 57.1 to 58.4).

We consider the Delaware River, PBF 2 to occur from approximately RKM 78 (where the final critical habitat 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 29,430 acres (NMFS 2019). We used DNREC's shapefile data "Delaware Bay Upper Shelf Bottom Sediments 2008-2010" (Metadata created 2015) to calculate soft substrate within this reach as 23,016 acres. However, since the action area does not include the bank-to-bank of the river channel but only includes the Project Area, the navigation channel between RKM 78 and 107.8, and the mitigation site (assuming it will be located just upstream of RKM 78), the action area only includes 2,604 acres[16] of the reach between the mouth of the river (RKM 78) and (RKM 107.8). The various acreages are presented below:

Feature	**Acreage**
River channel between RKM 78 and 107.8, bank to bank	29,430
PBF 2 (soft substrate between RKM 78-107.8)	23,016
Action Area between RKM 78-107.8	2,604
- Navigation Chanel between RKM 78 and 107.8	1,954
- Project Area	530
- Mitigation Area	120

Captured sturgeon and subsequent tracking studies have provided evidence that they use 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, juveniles will use the lower estuary for foraging year round with the most active foraging in these areas occurring in the spring to fall months and lighter foraging during the winter. Foraging is expected to occur over soft substrates that support the benthic invertebrates that juvenile Atlantic sturgeon eat. Later in the fall, larger, late-stage juveniles likely move out of this transitional zone into more saline waters in the lower Delaware River estuary (without leaving the estuary altogether, as that would indicate a transition to the subadult life stage), while the younger juveniles remain and either continue foraging, or move upstream to winter aggregation areas, such as those documented near Marcus Hook (ERC 2016, 2017, 2018, 2019, 2020b).

Activities that have impact PBF 2 include those that may alter salinity and those that result in the loss or disturbance of soft sediment within the transitional salinity zone. These include activities (e.g., disturbance of soft substrate by deep draft vessels) that result in sediment disturbance and subsequent sediment deposition that buries prey species (where that deposited sediment is not

[16] The project site is approximately 530 acres, the mitigation site is 120 acres, and the navigation channel between RKM 78 and 107.8 is approximately 1,954 acres.

immediately swept away with the current), direct removal or displacement of soft bottom substrate (e.g., dredging, construction), activities that result in the contamination or degradation of habitat reducing or eliminating populations of benthic invertebrates, and activities that influence the salinity gradient (e.g., climate change, deepening of the river channel, and flow management).

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

If shoaling occurs within the channel, the shoals are subsequently removed when they become obstacles for navigation. The removal of sediments to restore navigational depths also removes many benthic invertebrates. While recolonization may begin quickly after dredging is completed, it may take up to one year for those areas to be fully recolonized by benthic invertebrates.

As noted above, we estimate that 23,016 acres potentially meet the criteria for PBF 2 within critical habitat in the river. The navigation channel in this same reach of the river (RKM 78-107.8) encompasses an area of approximately 1,954 acres. Therefore, up to 8.5 percent of the area where we expect PBF 2 to occur is subject to vessel disturbance (assuming all habitat in the navigation channel in this reach meets the criteria for PBF 2). Dredging to remove shoals occurs in a smaller percentage of that total area within the channel.

However, we estimate that 2,604 acres of the action area occur within PBF 2 (1,954 acres of Navigation Channel + 530 acres of Project Area + 120 acres of mitigation). Of this, the navigation channel encompasses approximately 75 percent of PBF 2 within the action area (assuming all habitat in the navigation channel in this reach meets the criteria for PBF 2).

As described in Section 6.1.2.2, water pollution and contamination have historically been, and continue to be, an issue in the Delaware River, despite significant progress in limiting pollution and improving water quality in the past few decades. Point source discharges (i.e., municipal wastewater, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of benthic fauna consumed by foraging juvenile sturgeon in the transitional salinity zone. We consider the impacts of climate change in Section 3.0.

Physical and Biological Feature 3

Water of appropriate depth and absent physical barriers to passage between the river mouth and spawning sites necessary to support: (i) Unimpeded movement of adults to and from spawning sites; (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of subadults or spawning condition adults, are present throughout the extent of critical habitat designated in the Delaware River; therefore, PBF 3 is present within the action area.

Water depths in the main river channels, including the Port site portion of the action area, is also deep enough (*e.g.*, at least 1.2 m) to ensure continuous flow in the main channel at all times during which any sturgeon life stage is present in the river. Therefore, PBF 3 overlaps with the navigation channel between RKM 78 to RKM 214 and the Project Area. Physical barriers that may impede sturgeon passage include (but are not limited to) locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc. Sturgeon need to be able to make unimpeded movements up and downstream at all life stages. Adults must be able to stage before spawning and then move to and from the river mouth to spawning sites; subadults need to be able to enter the river for foraging opportunities; and juveniles must be able to move between appropriate salinity zones, foraging areas, and overwintering sites.

While there are some impediments to sturgeon movements (i.e., piers, pilings, etc. that sturgeon maneuver around within the river) there are no permanent barriers to movement within the action area. In addition to navigating around existing structures, sturgeon movements are also impacted by gear set in the river, vessel traffic, and in-water stressors from ongoing construction projects (e.g., turbidity from dredging, sound pressure waves from pile driving, etc.). Studies have shown that even in close proximity to active dredging equipment, sturgeon pass through the area, while showing little to no sign of disturbance (Balazik *et al.* 2021, Moser and Ross 1995, Reine *et al.* 2014).

Physical and Biological Feature 4

Water between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that combined support spawning, survival, and larval, juvenile, and subadult development and recruitment may be present throughout the extent of critical habitat designated in the Delaware River (depending on the life stage). Therefore, PBF 4 is present within the action area.

Water quality factors such as temperature, salinity and DO are interrelated environmental variables, and in a river system such as the Delaware, are constantly changing from influences of the tide, weather, season, etc. DO concentrations in water can fluctuate given a number of factors including water temperature (e.g., cold water holds more oxygen than warm water) and salinity (e.g., the amount of oxygen that can dissolve in water decreases as salinity increases). As such, DO levels that support growth and development will be different at different combinations of water temperature and salinity. Similarly, the DO levels that we would expect Atlantic sturgeon to avoid would also vary depending on the particular water temperature, salinity, and life stage.

As DO tolerance changes with age, the conditions that support growth and development, including the DO levels that may be avoided, also change (82 FR 39160; August 17, 2017).

On top of natural fluctuations in water quality, a number of human activities directly affect the temperature, salinity, and oxygen values within the Delaware River (also see discussion in Section 6.1). Water pollution, whether it be urban and rural runoff, combined sewer overflows (CSOs), accidental spills (e.g., Delaware River and Bay Oil Spill Advisory Committee 2010), or thermal plumes from nuclear generating stations (e.g., Salem and Hope Creek, Section 6.3.2) impact the water quality parameters in PBF 4. Construction activity also affects water quality. Turbidity from dredging or vessel activity that affects soft substrate may decrease levels of light and impact temperature. Dredging has the potential to increase water depths and cause cooling at the bottom of the water column (i.e., deeper water receives less light). Climate change, the effects of which are discussed in Section 7.0, will likely lead to an upstream shift in the salt front resulting from rising sea levels. High salinity prevents spawning and rearing of early life stages and YOY within the action area but increases in salinity may shift the distribution of juveniles and subadults. However, at this time, we do not have enough information to predict how climate change would affect juvenile and subadult development and recruitment.

Overall, water quality in the Delaware River has improved dramatically since the mid-20th century. In the late 1800s into the mid-1900s, water pollution still caused much of the lower Delaware River to be anoxic in the summer and fall months (Environmental Baseline, section 6.0), which created a barrier for diadromous fish passage. Two major causes of the turnaround in water quality were the passage of the Federal Water Pollution Control Act in 1948 (later amended in 1972 and more commonly called the Clean Water Act) and the creation of the DRBC, a federal-interstate agency created in October 1961. The most recent Delaware River and Bay Water Quality Assessment (DRBC 2020) concluded that the location of the proposed Port meets DRBC's water quality standard for dissolved oxygen in is a 24-hour average concentration not less than between 4.5 mg/L and 6.0 mg/L.

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

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

6.3.1 The Delaware River Federal Navigation Projects

The USACE have conducted annual maintenance dredging of the Delaware River for over 70 years. A batched consultation was completed in 1996 between us and the USACE on the effects on listed species and their habitat of the USACE's maintenance of the Philadelphia to Trenton Federal Navigation Channel, maintenance of the Philadelphia to the Sea Federal Navigation Channel, and dredging projects conducted by private applicants and authorized by the USACE.

Since 2008, the USACE have been working with us to consider effects of the deepening of the Philadelphia to the Sea Federal Navigation Channel from 40 to 45 ft (with 2 ft over-dredge) MLLW. A formal consultation was completed with issuance of a biological opinion dated July

17, 2009. The biological opinion concluded that dredging and rock blasting to deepen the channel from 40 ft to 45 ft may adversely affect, but is not likely to jeopardize the continued existence of shortnose sturgeon. In 2012, we listed the Atlantic sturgeon, and, consequently we reinitiated the consultation, and issued a biological opinion dated July 11, 2012. This consultation was again reinitiated in January, 2014 and again in November, 2015. The 2015 consultation included the use of a trawl to capture and relocate sturgeon from the blast site in the weeks before and during blasting. Both the 2014 and the 2015 biological opinions concluded that the proposed project may adversely affect, but is not likely to jeopardize the continued existence of shortnose sturgeon and Atlantic sturgeon.

We published two proposed rules (81 FR 35701; 81 FR 36078) to designate critical habitat for the five distinct population segments of federally listed Atlantic sturgeon on June 3, 2016. Consequently, the USACE requested a conference to consider the effects of the remaining deepening project, Philadelphia to the Sea maintenance, and Philadelphia to Trenton maintenance. To streamline and consolidate these consultation processes, we (NMFS and the USACE) agreed to complete a new consolidated biological opinion to include the effects of the Delaware River channel deepening project, Philadelphia to the Sea maintenance dredging and Philadelphia to Trenton maintenance dredging. The USACE also requested that we include a new project, the Delaware River Dredged Material Utilization (DMU) study. On November 17, 2017, we issued a new, consolidated biological opinion that replaced the previous opinions covering these activities:

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

The 2017 Opinion included an analysis of the projects' effects on designated Atlantic sturgeon critical habitat, as we published the final rule in the Federal Register on August 17, 2017 (82 FR 39160; effective date: September 18, 2017). We reinitiated this consultation in 2018 and issued a new biological opinion on December 10, 2018. In 2019, USACE informed us that they needed a fifth season using explosives to remove additional rock pinnacles in the navigation channel that could not be removed with dredging equipment. We again reinitiated the consultation based on the USACE proposal to conduct additional blasting that was not considered in the 2018 biological opinion. On November 22, 2019, we issued the last biological opinion on the deepening and maintenance of the Philadelphia to the Sea Federal Navigation Project (FNP), the Philadelphia to Trenton FNP, and the DMU study. The biological opinion considered the deepening blasting, the associated sturgeon relocation trawling proposed to be conducted during the winter of 2019 and 2020, and 50 years of maintenance dredging (2020 to 2070) of the two FNPs.

The 2019 biological opinion concluded that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon and the GOM, NYB, CB, and SA DPSs of Atlantic sturgeon. The biological opinion concluded that the proposed project was not likely to adversely affect Atlantic sturgeon from the Carolina DPS. We also determined that the proposed action is not likely to adversely affect critical habitat designated for the NYB DPS of Atlantic sturgeon

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, we determined that 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.

6.3.1.1 Delaware River Philadelphia to Trenton Maintenance Dredging Program

The Philadelphia to Trenton FNP is upstream of the site of the proposed NJWP. The only activity within this reach of the river that is related to the proposed project evaluated in this biological opinion is the use of tugboats and barges to transport material and equipment to the Port.

The USACE maintains to 40-ft depth the Delaware River Navigation Channel from Allegheny Avenue in Philadelphia (RKM 176.9) to Newbold Island in Bucks County (RKM 191.3), north of Philadelphia. From there, the USACE maintains navigation channels of varying authorized depths to the upstream limit of the FNP (RKM 214.5) just below the Penn-Central R.R. Bridge crossing over the Delaware River at Trenton, NJ. Dredging is completed by hydraulic dredging, bucket dredging, or hopper dredge and dredged material is transported to either Fort Mifflin or Palmyra Cove for containment. Table 21 shows the frequency of maintenance dredging, expected volume dredged, and the periods when dredging can occur for each reach of the Philadelphia to Trenton FNP.

Dredging of the Philadelphia to Trenton project has resulted in shortnose sturgeon mortality. In mid-March 1996, three fresh 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. In January 1998, three shortnose sturgeon were discovered in the hydraulic maintenance dredge spoil in the Florence to Trenton section of the upper Delaware River. These fish also appeared to have been alive and in good condition prior to entrainment (NMFS 2015). All of the shortnose sturgeon that were entrained in the cutterhead dredge occurred during dredging in or near aggregation areas during winter. Since 1998, the USACE have been avoiding dredging in the overwintering area during the time of year when shortnose sturgeon are present. The biological opinions for the Philadelphia to Trenton FNP as well as the subsequent consolidated biological opinions have required observation of the dredge spoils during hydraulic cutterhead dredging, and the USACE has not reported additional take of sturgeon from this project.

Since the 2015 biological opinion, maintenance dredging of the 40-foot Philadelphia to Trenton channel has resulted in three Atlantic sturgeon (dead) and one shortnose sturgeon (dead). All of the sturgeon takes occurred during hopper dredging.

6.3.1.2 Philadelphia to the Sea FNP Deepening and Maintenance

As reported in the 2015 Biological Opinion, the Delaware River Stem and Main Channel Deepening Project began in March 2010. The USACE completed the deepening of the channel from 40 ft to 45 ft in 2020. Maintenance dredging of the 40-foot channel has occurred since the

1970s until completion of the deepening in 2020. The 2019 biological opinion for the Delaware River FNPs covers 50 years of maintenance dredging of the 45-foot channel.

The Philadelphia to the Sea FNP is divided into river reaches from AA to E. Reach E is the downstream end of the channel in the Delaware Bay that starts at RKM 5 and the uppermost reach, Reach AA, ends at Allegheny Avenue in Philadelphia (RKM 176.9). The NJWP access channel will connect with the Philadelphia to the Sea at Reach D (Figure 20).

Figure 20. Illustration of the Deepening Project. Figure provided by USACE Philadelphia District.

The Philadelphia to the Sea Deepening

Prior to completion of the deepening project, the USACE maintained the channel at a depth of 40 ft at MLLW. Only portions of the channel that were between 40 ft and 45 ft MLW were dredged for the deepening project. Explosives were used to deepen the channel in Reach B (Marcus Hook and Chester Ranges) where rock and hard substrate precluded dredging. Blasting occurred over five consecutive winters from 2015 to 2020. Relocation trawling for sturgeon occurred three weeks prior to blasting and during blasting. Relocation trawling consisted of trawling the blasting area and transport all sturgeon caught upriver near Trenton, NJ, where they were released.

The surface area of the Delaware estuary from the Ben Franklin Bridge to the capes (excluding tidal tributaries) is approximately 700 square miles. The Philadelphia to the Sea Federal Navigation Channel has a surface area of 15.3 square miles, or approximately 2.2 percent of the total estuary surface area, of which 8.5 square miles has been dredged to 45 ft.

The Philadelphia to the Sea Maintenance Dredging

The USACE has maintained the Philadelphia to the Sea Channel at 45 ft since the completion of the deepening in 2020. Maintenance dredging in the river typically occurs between August and December using a hydraulic cutterhead dredge. Both the federally owned hopper dredge, McFarland, and other large hopper dredges and hydraulic cutterhead dredges are used. Material excavated from the river is placed in existing upland CDFs located along the Delaware River or in the open water disposal site Buoy 10 in the Delaware Bay (NMFS 2019). Table 22 shows the frequency of maintenance dredging, expected volume dredged, and the periods when dredging can occur for each reach of the Philadelphia to the Sea FNP.

Table 21. Philadelphia to Trenton proposed maintenance activities, methods, and dates (NMFS 2019).

Activity	Channel Reach/ Location	River miles & (RKM)	Duration (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applic-able)	Scheduled Dates
Maintenance dredging	A-B (Allegheny Ave., Philly to Burlington Island)	109.93-118.87 (176.9-191.3)	1-3	Annual	40' deep; 400' wide	100,000-200,000	Hopper, Cutter-head, or Mech-anical	Palmyra Cove, Burlington Island, Money Island, Biles Island, Ft. Mifflin	June 1 – March 15
Maintenance dredging	A-B (Burlington Island to Newbold Island, Bucks County)	118.87-126.88 (191.3-204.2)	1-3	2-3 year cycle	40' deep; 400' wide	700,000	Cutterhead or Mechanical	Money Island, Biles Island	July 1 – March 15 (Mechanical); July 1 – December 31 (Cutterhead)
Maintenance dredging	B-C (Newbold Island to Trenton Marine Terminal)	128.66-132.06 (207.1-212.5)	10-20 days	3-5 years	25' deep; 300' wide	150,000	Cutterhead or Mechanical	Money Island, Biles Island	July 1 – March 15 (Mechanical); July 1 – December 31 (Cutterhead)
Maintenance dredging	C-D	132.07-133.29 (212.5-214.5)	1-3	Not routinely maintained	12' deep; 20' wide	<100,000	Cutterhead or Mechanical	Money Island, Biles Island	Oct. 1 – March 15
Maintenance dredging	Fairless Turning Basin	126.88 (204.2)	1	2 year cycle	40'	200,000	Cutterhead	Money Island	July 1 – March 15

Table 22. Philadelphia to the Sea proposed maintenance activities, methods, and dates (NMFS 2019). Shaded row indicates the reach where the Project Area of this consultation is located.

Activity	Channel Reach/ Location	River miles & (RKM)	Duration (mo.)	Dredge Frequency	Dredge Depth/ Width	Vol. (CY)	Type of Dredge/ Equipment	Disposal location (if applic-able)	Scheduled Dates
Maintenance dredging	E	5-41 (8-66)	2-3	Annual	45'	400,000	Hopper	Buoy 10	All Year
Maintenance dredging	D	41.1-55 (66.1-88.5)	2-3	3-Year Cycle	45'	1,000,000	Hopper & Cutterhead	Artificial Island CDF	All Year
Maintenance dredging	C	55.1-67 (88.7-107.8)	2-3	Annual	45'	2,000,000	Cutterhead & Hopper	Killcohook and Pedrick-town CDFs	All Year
Maintenance dredging	B	67.1-85 (108-136.8)	2-3	Annual	45'	2,700,000	Hopper & Cutterhead Suction & Mechanical	Oldmans and Pedrick-town CDFs	July 1 – March 15
Maintenance dredging	A	85.1-97 (137-156.1)	2-3	5-Year Cycle	45'	200,000	Mechanical & Hopper & Cutterhead	National Park & Fort Mifflin CDFs	July 1 - March 15
Maintenance dredging	AA	97.1-102 (156.3-164.2)	2-3	5-Year Cycle	45'	450,000	Mechanical & Hopper	National Park & Fort Mifflin CDFs	July 1 – March 15

6.3.1.3 2019 Biological Opinion ITS

The 2019 biological opinion concludes that the proposed action has the potential to result in the mortality of 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 concluded that the proposed project may affect but is not likely to adversely affect critical habitat designated for Atlantic sturgeon. We estimated that, on average, one sturgeon of either species will interact with a hopper dredge for every 2,496,000 CY of material dredged. In the 2019 biological opinion, we determined that the anticipated take is not likely to jeopardize the continued existence of listed species. The biological opinion exempts 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 2019 and 2020. Of the eight, an undetermined fraction will be shortnose sturgeon and an undetermined fraction will be Atlantic sturgeon NYB DBS.
- The lethal take of up to 13 sturgeon takes as a consequence of handling stress and relocation of sturgeon, any combination of adult and/or juvenile shortnose and juvenile Atlantic sturgeon (NYB DBS).
- The lethal take by dredging entrainment/entrapment of up to 116 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 50 years or until 2070.
- Of the 116 sturgeon killed, incidental take of up to 67 Atlantic sturgeon New York Bight DPS.
- Of the 116 sturgeon killed, incidental take of up to 21 Atlantic sturgeon Chesapeake Bay DPS.
- Of the 166 sturgeon killed, incidental take of up to 20 Atlantic sturgeon South Atlantic DPS.
- Of the 116 sturgeon killed, incidental take of up to 8 Atlantic sturgeon Gulf of Maine DPS.
- Lethal take of an unquantified number of post yolk sac Atlantic sturgeon New York Bight DPS larvae.

The incidental take statement (ITS) also exempts the capture/collection of up to 1,663 sturgeon (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon) during relocation trawling project carried out over the blasting season (December 1, 2019-March 15, 2020). Of the 1,663, 100 sturgeon may be injured from surgery to install acoustic tags (any combination of NYB DPS Atlantic sturgeon and shortnose sturgeon).

6.3.2 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 biological opinion (NMFS 2014), we concluded that the continued operation of the Salem 1, Salem 2 and Hope Creek Nuclear Generating Stations through the duration of extended operating licenses may adversely affect, but is not likely to jeopardize, the continued existence of any listed species. In 2020, we reinitiated consultation between NRC and NMFS on the effects of the operation of these facilities, and the consultation is ongoing. Therefore, we rely on the ITS of the 2014 biological opinion.

As described in Table 23 through Table 25 below, the ITS of the Salem and Hope Creek Generation Stations 2014 biological opinion exempts take (injured, killed, capture or collected) of 26 shortnose sturgeon and 500 Atlantic sturgeon 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 five DPSs) during gillnet sampling associated with the Radiological Environmental Monitoring Program for either Salem 1, Salem 2, or Hope Creek. We did not identify any ESA-listed whale species within the Salem and HCGS action area (NMFS 2014).

As explained in the 2014 biological opinion, we also determined that the Improved Biological Monitoring Work Plan (IBMWP), required by the NJPDES permit issued to PSEG for the operation of Salem 1 and 2, including the bay-wide trawl survey and beach seine sampling, is an interrelated activity (another activity that is caused by the proposed action). Thus, in the Effects of the Action section, we considered the effects of the IBMWP. We estimated that the continuation of the bottom trawl survey will result in the non-lethal capture of 9 shortnose sturgeon and 11 Atlantic sturgeon (6 NYB, 2 CB, and 3 SA, GOM or Carolina DPS). We also expect the beach seine survey to result in the non-lethal capture of one Atlantic sturgeon (likely NYB DPS origin) and one shortnose sturgeon. The ITS exempts this amount of take ("capture" or "collect") of live shortnose sturgeon and Atlantic sturgeon incidentally captured during these surveys.

Table 23. 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 24. 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 or Carolina DPS	1 dead or alive from either the CB, SA, GOM or Carolina DPS	Total of 2 from the CB, SA, GOM and/or Carolina DPS

Table 25. 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)

6.3.3 Delaware River Partners (DRP) Marine Terminal

On December 8, 2017, we issued a biological opinion to the USACE for the development by the Delaware River Partners, LLC (DRP) of a multiuse deep-water seaport and international logistics center (DRP Port) on a portion of the former Dupont Repauno Property in Gibbstown, New Jersey at RKM 139/RM86.5 (NMFS 2017b). Thus, the port is located outside of the action area for this consultation. However, the biological opinion considered the consequences of vessels traffic that would travel between the Pilot Area at the mouth of the Delaware River and the DRP Port. Therefore, the action area for the DRP Port overlaps with the action area for this consultation.

The proposed multiuse terminal will support automobile import and processing, perishables and bulk cargo handling, and bulk energy liquid products storage and handling. The development included dredging of an approach channel for vessels up to 870 feet and 30- to 40-foot deep draft, two berths with mooring dolphins, an auto terminal, a cargo area, facilities for bulk liquid energy storage, and warehouses. Estimated vessel traffic is 133 vessel calls per year. Of these, the USACE considered 91 vessel calls as new vessels to the Delaware River and the remaining 41 Roll On/Roll Off (RoRo) vessel calls to be vessels diverted and redistributed from existing terminals. Since vessel strikes are a stressor associated with vessel traffic, we determined that vessel traffic between the Pilot Boarding area at the mouth of the Delaware Bay and the proposed terminal was an activity interrelated to the proposed action. Thus, the action area for the proposed NJWT consultation overlaps with the action area for the DRP port from RKM 86/RM 53.5 to the end of the federal navigation channel, the precautionary area, the connecting channel, and the pilot area.

In the biological opinion, we concluded that construction activities were not likely to adversely affect listed species or critical habitat designated for Atlantic sturgeon. However, we did determine that the transit of RoRo vessels interrelated to operation of the terminal will entrain and kill up to six adult sturgeon during the 30 years of terminal operation (until 2047). Four of these are likely to belong to the NYB DPS, one to CB DPS, and one from either SA DPS or GOM DPS. We also determined that it is likely that RoRo vessels transiting the Delaware River during 30 years of terminal operation would result in the vessel strike mortality of one adult shortnose sturgeon. However, we concluded that these effects would not jeopardize the continued existence of these species. We concurred that the effects of the construction and operations of the facility were not likely to adversely affect listed sea turtles and whales.

On September 26, 2019, USACE sent us a request for reiniation of consultation and a biological assessment for the development of a second dock (Dock 2) that can handle two vessels simultaneously. The applicant proposed to change operations of Dock 1 from RoRo cargo to on/off loading of liquid energy products and to construct an additional dock specifically to be used to trans-load liquid energy products to two vessels simultaneously (allowing three vessels to be in port at any given time). Based on these changes, USACE informed us that they had determined that the proposed modifications would not change the number of vessels using the terminal (the existing dock and proposed dock combined) because handling of liquefied energy products requires a substantially longer docking time per vessel. However, because the construction of the additional dock included dredging of 45 acres of river bottom and the placement of numerous steel piles in the river, the USACE determined that the modifications would result in effects that were not considered in the previous biological opinion.

Combined, the dredging and use of the former and proposed access channels and berths will affect approximately 72 acres of benthic habitat and fauna. The proposed construction of the new wharf included pile driving of 280 24” to 48” steel piles and added another season of driving of piles. The proposed new dock will have an over-water footprint of 3.2 acres that added to the footprint of the wharf considered in the previous consultation. However, since the number of new vessel calls would not change, the USACE determined that the proposed modification to the project would not result in additional adverse effects to what were considered previously and that the proposed project was not likely to adversely affect (NLAA) listed species. On November 19, 2019, we issued a letter where we concurred with the USACD NLAA determination.

6.4 Federal Actions that have Undergone Informal Consultations

Several federally authorized private projects in the Delaware River have undergone informal consultation. These projects includes dredging, construction (including pile driving), and vessel traffic associated with construction and operations of the new or modified port facilites discussed below. No interactions with ESA-listed sturgeon have been reported in association with any of these projects, nor has any take been authorized. We also concluded that the proposed projects may affect but is not likely to adversely affect critical habitat designated for Atlantic sturgeon.

No other critical habitat designated for other species occur within the action areas for these projects.

6.4.1 Consultations on Port and Terminal Constructions

6.4.1.1 Liberty Terminal (NAP-2016-00978-24)

In 2021, the USACE proposed to issue a Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344) to Liberty Terminal at Pennsauken Urban Renewal, LLC. The permit would allow the repair/rehabilitation of an existing dock facility to its intended purpose (i.e. loading of petroleum related product to land - based storage tanks) and bring the facility to modern working standards. In a letter dated September 2, 2021, we concurred with the USACS' determination that the proposed project may affect, but is not likely to adversely affect listed species under our jurisdiction or designated critical habitat.

The terminal is located in Pennsauken Township, Camden County, New Jersey at RKM 167 (RM 104). The proposed project included pile driving for construction of a new loading platform, mooring dolphins, and catwalks. The applicant did not propose dredging of the berth as the channel already is deep enough for vessels to dock at the landing platform. The proposed project also included increasing the pipe diameter of two outfalls and placing protective riprap to protect the shoreline from scouring.

The applicant anticipated up to 120 tug-supported barges annually calling at the terminal during operation of the terminal. No more than one barge would be moored at any one time. According to the USACE, the applicant's marketing plan is based on attracting customers from other terminals in the area as the Liberty terminal will be a state of the art facility meeting or exceeding all terminal services provided by the existing old facilities and having the most up to date safety and emissions standards. The USACE concluded that the Liberty Terminal will be serving a portion of the refinery market that already uses the existing river traffic, and their operation would only replace a small fraction of this supply and demand. Therefore, the proposed project would not add vessels to the existing baseline as the need for transporting refinery products would occur irrespective of the proposed terminal.

6.4.1.2 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 42 RKM (26 RM) upstream of the proposed NJWP. The USACE issued a Public Notice on August 3, 2015, for the modification of the existing Dock IA to allow for the on-loading 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, with work including the demolition of existing marine structures and construction of a new approach way, 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. 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. In communication to us (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, we agreed with USACE's determination that the project was not likely to adversely affect and listed species in NMFS jurisdiction. 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. We 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 expected, NMFS concluded that there would be no increased risk of vessel strike in the future.

6.4.1.3 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, Philadelphia Regional Port Authority, proposed to construct a new marine terminal on approximately 116 acres of currently vacant land. 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 consultation considered the consequences from the dredging of approximately 35 acres within the Delaware River, construction of a pile supported wharf, installation of 2,400 linear feet of riprap along the Delaware River shoreline, filling of approximately 11 acres of aquatic habitat within the Delaware River, and the maintenance dredging of the berths with the removal of approximately 20,000 cy of material every two years. In addition, the consultation also considered the consequences of vessels traveling between the port and the mouth of the Delaware Bay during operation of the port. The USACE and applicant anticipated that the port would receive 260 cargo vessel calls per year. The Section 10/404 Permit was issued by the USACE on April 16, 2013. However, 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 of an auto terminal 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). The development was completed in 2019. In late 2019, the USACE informed us that the applicant had requested an extension of the permit to allow for completion of the work as proposed in the original 2013 consultation. The USACE requested a reinitiation of the consultation to address consequences to critical habitat designated for Atlantic sturgeon in 2017. Consequently, in a letter dated January 22, 2020, we concurred with the USACE's determination that the proposed project may affect but is not likely to adversely affect critical habitat designated for Atlantic sturgeon.

6.4.1.4 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). 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[17] 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 one and the 95% confidence interval was 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 or Atlantic sturgeon. Listed whales were not identified to be present within the PMT action area (which included the Philadelphia to the Sea Navigation Channel from the port to the mouth of the Delaware River) 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. Phase 1 of the project was completed. However, the permit expired and in 2018 the USACE requested reinitiation of the consultation to consider the consequences of completing Phase 2 of the project on the listed Atlantic sturgeon and the designated critical habitat for Atlantic sturgeon. All dredging had been completed during Phase 1 and the consultation only considered the consequences of pile driving for the construction of wharf structures. On August 31, 2021, we issued a letter concurring with the determination by the USACE that the proposed project may affect but is not likely to adversely affect Atlantic sturgeon or Atlantic sturgeon critical habitat.

6.4.1.5 Vessel Operations

Potential sources of adverse effects from federal vessel operations in the action area of this biological opinion include operations of the U.S. Navy (USN) and the U.S. Coast Guard (USCG) (which maintain the largest federal vessel fleets), the EPA, the National Oceanic and

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17 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.

Atmospheric Administration (NOAA), and USACE. We have conducted formal consultations with the USCG, the USN, EPA and NOAA on their vessel operations. In addition to operation of USACE vessels, we have consulted with the USACE to provide recommended permit restrictions for operations of contract or private vessels around whales. Through the section 7 process, where applicable, we have and will continue to establish conservation measures for all these agency vessel operations to avoid adverse effects to listed species. Refer to the biological opinions for the USCG (September 15, 1995; July 22, 1996; and June 8, 1998) and the USN (May 15, 1997) for detail on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures. No interactions with sturgeon have been reported with any of the vessels considered in these biological opinions. The effects of vessels (private and commercial) in the action area are further considered in section 4.4.

6.4.1.6 Other Projects

We have completed several other informal consultations on effects of in-water construction activities in the Delaware River permitted by the USACE. This includes several pier reconfiguration and maintenance dredging projects. No interactions with ESA-listed species 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 listed species have been reported in association with any of these projects.

On April 12, 2017, we completed an informal, programmatic consultation pursuant to section 7 of the Endangered Species Act (ESA) of 1973, as amended, for six categories of projects regularly permitted, funded, or otherwise carried out by the USACE (the NLAA program). Proposed projects within these activity categories will be covered by the programmatic consultation provided they meet the project design criteria (PDC) that are outlined in this programmatic consultation. In our April 12, 2017, letter to USACE, we concurred with their determination that the consequences of individual projects as well as the aggregate consequences of projects included in the NLAA program may affect but are not likely to adversely affect listed species or designated critical habitat. For any project USACE considered covered under the program, they will provide us with a form verifying that each PDC is met or a justification for why they believe that the project fits under the program even if some PDC are not met. If we agree with their determination that a project fits under the program, we will sign the form.

We have included several in-water construction activities in the Delaware River permitted by the USACE under the NLAA program. These include dock and pier repairs, bank stabilization projects, aquaculture projects, and routine maintenance dredging activities. No interactions with ESA-listed species have been reported in association with any of these projects, nor has any take been authorized.

6.5 Scientific Studies

NMFS has issued research permits under section 10(a)(1)(A) of the ESA, which authorizes activities for scientific purposes or to enhance the propagation or survival of the affected species. The permitted activities do not operate to the disadvantage of the species and are consistent with the purposes of the ESA, as outlined in section 2 of the Act. The following section 10(a)(1)(A) permits are currently in effect for Atlantic sturgeon and shortnose sturgeon.

We searched for research permits on the NOAA Fisheries' online application system for Authorization and Permits for Protected Species (APPS) interactive website[18]. The search criteria used confined our search to active permits that include take of sturgeon within the Delaware River and Bay as well as research in coastal waters off Delaware and New Jersey.

There are currently five research permits pursuant to 10(a)(1)(A) of the ESA that authorize research of sturgeon in the Delaware River/Bay (Table 26 and Table 27). However, many research activities include a larger area of the Atlantic Ocean, and the requested take did not always specify the waters where take would occur. Thus, some of the requested take in the tables below include take for activities outside of the action area, i.e., mid-Atlantic coastal waters in general.

The requested take reported here only includes take authorized under section 10(a)(1)(A) of the ESA. In addition, research projects may include take authorized under other authority, e.g., under section 7 of the ESA. These takes are presented elsewhere in this Opinion and, therefore, are not included here to avoid double counting of take provided under the ESA.

Table 26. Shortnose sturgeon section 10(a)(1)(A) permits within the action area.

Permittee	File #	Project	Area	Shortnose Sturgeon Takes	Research Timeframe
School of Marine and Atmospheric Sciences, Stony Brook University	20351	Atlantic and Shortnose Sturgeon Population Dynamics and Life History in New York and Coastal Marine and Riverine Waters	Marine aggregation areas located in New York, New Jersey, Delaware, and Connecticut waters. Riverine and estuarine areas of the Hudson and Delaware Rivers.	<u>Lethal</u> Incidental mortality - 1 Adult/Sub-adult[19] - 1 Juvenile Direct mortality - 80 early life stages annually with no more than a total of 160 <u>Non-lethal</u> Gill net - 285 adults, 195 sub-adults, 195 juveniles, capture/handle/release, annually Trawl 285 adults, 195 sub-adults, 195 juveniles, capture/handle/release, annually	10 years, 02/27/2016 to 03/31/2027
Dewayne Fox, Assistant Professor, Delaware State University, Dept. of Agriculture and Natural Resources	20548	Reproduction, habitat use, and interbasin exchange of Atlantic and	- Marine waters between Virginia and New York. - Delaware Bay and Delaware River and estuary.	<u>Lethal (annually)</u> Incidental mortality	10 years, 03/31/2017 to 03/31/2027

[18] APPS website URL: https://apps.nmfs.noaa.gov/index.cfm

[19] Although GARFO does not include the term "sub-adult" as a lifestage for shortnose sturgeon, the term is often used by researchers and managers to indicate larger and older shortnose sturgeon individuals that have not yet reached maturity (i.e. adult phase). The application for permit 20351 states the sub-adult lifestage to range from 1000–1300 mm FL, while GARFO considers shortnose sturgeon ranging from 140 to 450 mm (in the northern part of their range) to be juveniles and sturgeon greater than 450 mm are considered to be adults.

Permittee	File #	Project	Area	Shortnose Sturgeon Takes	Research Timeframe
		Shortnose Sturgeons in the mid-Atlantic	- Hudson River and estuary	- 1 adult/sub-adult[20] <u>Non-lethal (annually)</u> - 150 adult, capture/handle/release, in each of Delaware and Hudson Rivers (Spawning Site Identification) - 100 adult, sub-adult from each of Delaware and Hudson Rivers (Hydroacoustic Assessment)	
Delaware Department of Natural Resources and Environmental Control	24020	Characterizing juvenile life stages of endangered Atlantic and Shortnose Sturgeon in the Delaware River and Estuary.		<u>Lethal</u> Incidental mortality - 1 adult (no more than 2 for 10 yr permit period) - 1 juvenile (no more than 2 for 10 yr permit period) <u>Non-lethal</u> - 10 adult - 65 juvenile	10 Years, 01/28/2021 to 01/31/2031

Table 27. Atlantic sturgeon section 10(a)(1)(A) permits within the action area.

Permittee	File #	Project	Area	Atlantic Sturgeon Takes	Research Timeframe
North East Fisheries Science Center	17225	Conservation engineering to reduce sea turtle and Atlantic sturgeon bycatch in fisheries in the Northeast Region	U.S. Atlantic waters managed under the Mid-Atlantic and New England Fishery Management Council's Fishery Management Plans. Part A: from and including Massachusetts south to the North Carolina-South Carolina border. Part B: U.S. Atlantic waters off North Carolina, south to the border of Georgia and Florida	<u>Lethal:</u> Incidental mortality - 6 adult/juvenile <u>Non-lethal:</u> - 223 adult/juvenile sturgeon (Part A: Northern Area) - 204 adult/juvenile sturgeon (Part B: Southern Area)	5 years, 01/01/2017 to 12/21/2022 Extension granted 11/09/21 for 1 year or less.
School of Marine and Atmospheric Sciences, Stony Brook University	20351	Atlantic and Shortnose Sturgeon Population Dynamics and Life History in New York and Coastal Marine an Riverine Waters	Marine aggregation areas located in New York, New Jersey, Delaware, and Connecticut waters. Riverine and estuarine areas of the Hudson and Delaware Rivers.	<u>Lethal</u> Incidental mortality - 1 Adult/Sub-adult - 2 Juvenile Direct mortality - 80 early life stages annually with no more than a total of 160 <u>Non-lethal</u> Gill net	10 years, 02/27/2016 to 03/31/2027

[20] For permit 20548, the applicant describes the shortnose sturgeon sub-adult phase as ranging from 450– 600 mm FL.

Permittee	File #	Project	Area	Atlantic Sturgeon Takes	Research Timeframe
				- 71 adults, 352 sub-adults, 437 juveniles, 130 small juveniles, capture/handle/release, annually Trawl 71 adults, 352 sub-adults, 437 juveniles, 130 small juveniles, capture/handle/release, annually	
Dewayne Fox, Assistant Professor, Delaware State University, Dept. of Agriculture and Natural Resources	20548	Reproduction, habitat use, and interbasin exchange of Atlantic and Shortnose Sturgeons in the mid-Atlantic	- Marine waters between Virginia and New York. - Delaware Bay and Delaware River and estuary. - Hudson River and estuary	Lethal (annually) Direct mortality: - 150 early life stage from each of Delaware River and Hudson River Incidental mortality - 1 adult Non-lethal (annually) - 150 adult, capture/handle/release, in each of Delaware and Hudson Rivers (Spawning Site Identification) - 100 adult, sub-adult, and juvenile from each of Delaware and Hudson Rivers (Hydroacoustic Assessment) - 150 adults/sub-adults and/or juveniles, capture/handle/release, from Delaware River estuary, Bay, NJ near shore (Estuarine and Marine Foraging) - 300 adult and sub-adult and 150 juveniles, capture/handle/release(Coastal Sampling) - 300 early life stages from each of Delaware River and Hudson River, capture/handle/release (Spawning Site Identification)	10 years, 03/31/2017 to 03/31/2027
Delaware Department of Natural Resources and Environmental Control	24020	Characterizing juvenile life stages of endangered Atlantic and Shortnose Sturgeon in the Delaware River and Estuary.	- In the tidal portion of the Delaware River, with a majority of the sampling being completed in the Marcus Hook area (may be adjusted using telemetry data)	Lethal Incidental mortality - 1 adult/subadult (no more than 2 for 10 yr permit period) - 1 juvenile (no more than 2 for 10 yr permit period) Non-lethal - 10 adult/subadult - 340 juvenile	10 Years, 01/28/2021 to 01/31/2031

Section 10(a)(1)(B) Permits

Section 10(a)(1)(B) of the ESA authorizes NMFS, under some circumstances, to permit non-federal parties to take otherwise prohibited fish and wildlife if such taking is "incidental to, and not the purpose of carrying out otherwise lawful activities" (50 CFR 217-222). As a condition for issuance of a permit, the permit applicant must develop a conservation plan that minimizes negative impacts to the species.

Active permits and permit applications are posted online for all species as they become available at https://www.fisheries.noaa.gov/national/endangered-species-conservation/incidental-take-permits. Most coastal Atlantic states are either in the process of applying for permits or considering applications for state fisheries. We are actively working with several states and other parties on section 10(a)(1)(B) permits; however to date no section 10(a)(1)(B) permits have been authorized for Delaware, Pennsylvania, or New Jersey states fisheries. We have issued a permit to the Exelon Generating Company, LLC., for the withdrawal of water through the cooling intake. We issued a biological opinion for the permit on June 19, 2020 (NMFS 2020).

Permittee	Permit #	Project	Area	Atlantic Sturgeon Takes	Timeframe
Exelon Generating Company, LLC	23148	Operation of Eddystone Generating Station	Delaware River from 64 meters upriver from Eddystone (on the western shore of the Delaware River) downriver to the mouth, its tributary Crum Creek, and marine waters from the mouth of the Delaware River to New York Harbor.	New York Bight DPS Atlantic sturgeon Vessel Strike: 1 over 10 years (sub-adults/adults) Entrainment: 27,000 larvae (2 age-1 equivalents) per year Impingement: 5 per year (YOY/sub-adults) Total: 1 sub-adult/adult, 270,000 larvae, and 50 YOY/sub-adults over 10 years Shortnose sturgeon Impingement: 5 per year (YOY/sub-adults) Total: 50 YOY/sub-adults over 10 years.	10 Years, 07/06/2020 to 7/31/2030

6.6 State or Private Actions in the Action Area

6.6.1 State Authorized Fisheries

The action area includes portions of Pennsylvania, New Jersey and Delaware state waters within the Delaware River and Delaware Bay. Several fisheries for species not managed by a federal FMP occur in state waters. Atlantic and shortnose sturgeon may be vulnerable to capture, injury and mortality in a number of these fisheries. Atlantic sturgeon as well as shortnose sturgeon are also vulnerable to capture in state-water fisheries occurring in rivers, such as shad fisheries. Gear types used in these fisheries include hook-and-line, gillnet, trawl, pound net and weir, pot/trap, seines, and channel nets among others. The magnitude and extent of interaction, and the amount of gear contributed to the environment by all of these fisheries together is currently unknown.

Captures of Atlantic sturgeon (ASMFC 2017, ASSRT 2007) have been reported through state reporting requirements, research studies, vessel trip reports (VTRs), NEFSC observer programs, and anecdotal reports. In most cases however, there is limited observer coverage of these fisheries, and the extent of interactions with ESA-listed species is difficult to estimate. Information on the number of sturgeon interactions in state fisheries is extremely limited. The available bycatch data for FMP fisheries indicate that sink gillnets and bottom otter trawl gear pose the greatest risk to Atlantic sturgeon, although they are also caught by hook and line gear, fyke nets, pound nets, drift gillnets, and crab pots (ASMFC 2017). It is likely that this vulnerability to these types of gear is similar to federal fisheries, although there is little data available to support this. An Atlantic sturgeon “reward program” provided commercial fishermen monetary rewards for reporting captures of Atlantic sturgeon in Maryland’s Chesapeake Bay from 1996 to 2012 (Mangold *et al.* 2007). The data from this program show that Atlantic sturgeon have been caught in a wide variety of gear types, including hook and line, pound nets, gillnets, crab pots, eel pots, hoop nets, trawls, and fyke nets. Pound nets (58.9 percent) and gillnets (40.7 percent) accounted for the vast majority of captures. Of the more than 2,000 Atlantic sturgeon reported in the reward program over a 16-year period from 1996-2012, biologists counted ten individuals that died because of their capture. No information on post-release mortality is available (Mangold *et al.* 2007).

Efforts are currently underway by the Commission and the coastal states to assess the impacts of state authorized fisheries on sturgeon. Several states (including Delaware and New Jersey) are working on applications for ESA section 10(a)(1)(B) Incidental Take Permits to cover their fisheries; however, to date, no permit applications have been submitted to NMFS by states that authorize fisheries within the Delaware River/Bay[21]. Below, we discuss the different fisheries authorized by the states and any available information on interactions between these fisheries and sturgeon. Fisheries that use types of gear unlikely "to harass, harm…wound, kill, trap, capture, or collect" (ESA Section 2(a)(19)) sturgeon, or where there is no documented interactions of the fishery with sturgeon (e.g., American eel, American lobster, whelk) are not included.

Atlantic croaker fishery
Atlantic croaker (*Micropogonias undulates*) occur in coastal waters from the Gulf of Maine to Argentina, and are one of the most abundant inshore bottom-dwelling fish along the U.S. Atlantic coast. Recreational fisheries for Atlantic croaker are likely to use hook and line; commercial fisheries targeting croaker primarily use otter trawls. An Atlantic croaker fishery using trawl and gillnet gear also occurs within the action area and is managed under a Commission Interstate Fisheries Management Plan (ISFMP) (including Amendment 1 in 2005 and Addendum 1 in 2010), but no specific management measures are required. Atlantic croaker are seasonally present in Delaware Bay; fishing occurs for this species in the Bay but not in the river. Shortnose sturgeon are rare in the Delaware Bay and no interaction with shortnose sturgeon has been reported.

Atlantic sturgeon interactions have been observed in the Atlantic croaker fishery, but a quantitative assessment of the number of Atlantic sturgeon captured in the croaker fishery is not available. A mortality rate of Atlantic sturgeon in commercial trawls has been estimated at 5%. A review of the Northeast Fisheries Observer Program (NEFOP) database indicates that from 2006-2010, 60 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as croaker. This represents a minimum number of Atlantic sturgeon captured in the croaker fishery during this time period as it only considers trips that included a NEFOP observer onboard. Because the fishery occurs in the Bay, we do not anticipate any interactions with shortnose sturgeon.

Weakfish fishery
The weakfish fishery occurs in both state and Federal waters from Nova Scotia to southeastern Florida, but the majority of commercially and recreationally caught weakfish are caught in state waters (ASMFC 2002) from New York to North Carolina, including the Delaware Bay. The dominant commercial gears include gillnets, pound nets, haul seines, flynets, and trawls, with the majority of landings occurring in the fall and winter months (ASMFC 2002, Weakfish Plan Review Team 2019). Weakfish landings were dominated by the trawl fishery through the mid-

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

1980s, after which gillnet landings began to account for most weakfish landed (ASMFC 2002). Other gears include pound nets, haul seines, and beach seines (ASMFC 2016). The recreational fishery catches weakfish using live or cut bait, jigging, trolling, and chumming, and the majority of fish are caught in state waters.

In our 2021 biological opinion for the authorization of multiple fisheries (Batch BO), we determined that that it is extremely unlikely that the fisheries, including the weakfish fishery, considered in the biological opinion will interact with shortnose sturgeon. A quantitative assessment of the number of Atlantic sturgeon captured in the weakfish fishery is not available. A mortality rate of Atlantic sturgeon in commercial trawls has been estimated at 5 percent. Weakfish has also been identified as the top landed species on observed trips where sturgeon were incidentally captured (NEFSC observer/sea sampling database, unpublished data). In addition, the weakfish-striped bass fishery was identified as having higher bycatch rates using data from 1989-2000 (ASSRT 2007); however, there are a number of caveats associated with this data.

Crab fisheries

Crab fisheries use a variety of gears including hand, pot/trap, trawl, and dredge. These fisheries occur in federal and state waters and target species such as blue, Jonah, rock and horseshoe crab. While the blue crab fishery occurs throughout the Mid-Atlantic south to the Gulf of Mexico, Maryland, Virginia, and North Carolina harvesters execute the majority of the effort. The Chesapeake Bay Program’s Blue Crab Management Strategy indicates that there are multiple commercial and recreational gear types, various season lengths and regulations in three management jurisdictions. Fishing practices and the resulting harvest vary because of the complex ways crabs migrate and disperse throughout Chesapeake Bay.

The Jonah and rock crab fisheries may be carried out in conjunction with the lobster fishery. In this case, lobster traps are likely to be used. Depending on state regulation, other style traps may be available for use. Jonah crabs are harvested from deeper waters than rock crabs, and presently, are more highly valued. The commercial Jonah crab fishery is centered around Massachusetts and Rhode Island, though landings occur throughout New England and Mid-Atlantic states. The majority of horseshoe crab harvest comes from the Delaware Bay region, followed by the New York, New England, and the Southeast regions. Trawls, hand harvests, and dredges make up the bulk of commercial horseshoe crab landings.

Horseshoe crab fisheries occur in saline and marine waters and are unlikely to interact with shortnose sturgeon. Atlantic sturgeon are known to be caught in state water horseshoe crab fisheries using trawl gear (Stein *et al.* 2004a). With the exception of New Jersey state waters, the horseshoe crab fishery operates in all state waters that occur in the action area. Along the U.S. East Coast, hand, bottom trawl, and dredge fisheries account for the majority (86 percent in the 2017 fishery) of commercial horseshoe crab landings in the bait fishery. Other methods used to land horseshoe crab are gillnets, fixed nets, rakes, hoes, and tongs (ASMFC (Atlantic States Marine Fisheries Commission) 2019, Horseshoe Crab Plan Review Team 2019). For most states, the bait fishery is open year round. However, the fishery operates at different times due to movement of the horseshoe crab. New Jersey has prohibited commercial harvest of horseshoe crabs in state waters (N.J.S.A. 23:2B-20-21) since 2006 (Horseshoe Crab Plan Review Team 2019). Other states also regulate various seasonal and area closures and other state horseshoe crab fisheries are regulated with various seasonal/area closures (Horseshoe Crab Plan Review Team 2019). The majority of horseshoe crab landings from the bait fishery from 2014-2018 came from Maryland, Delaware, New York, Virginia, and Massachusetts (Horseshoe Crab Plan Review Team 2019). There is also a smaller fishery for biomedical uses.

An evaluation of bycatch of Atlantic sturgeon using the NEFSC observer/sea sampling database (1989-2000) found that the bycatch rate for horseshoe crabs was low, at 0.05 percent (Stein *et al.* 2004a). An Atlantic sturgeon "reward program," where commercial fishermen were provided monetary rewards for reporting captures of Atlantic sturgeon in the Maryland waters of Chesapeake Bay operated from 1996 to 2012.[22] From 1996-2006, the data showed that one of 1,395 wild Atlantic sturgeon was found caught in a crab pot (Mangold *et al*. 2007).

American shad fishery
An American shad fishery occurs in state waters of New England and the Mid-Atlantic and is managed under the Commission's ISFMP. Amendment 3 to the ISFMP requires states and jurisdictions to develop sustainable FMPs, which are reviewed and approved by the Commission's Technical Committee, in order to maintain recreational and commercial shad fisheries (ASMFC 2010). In 2005, the directed at-sea fishery was closed and subsequent landings from the ocean are only from the bycatch fishery. In 2012, only one commercial fishing license was granted for shad in New Jersey. The fishery occurs in rivers and coastal ocean waters and uses five-inch mesh gillnets left overnight to soak. Based on the available information, there is little bycatch mortality.

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. Recreational hook and line shad fisheries are known to capture shortnose sturgeon and Atlantic sturgeon. Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the shad fishery accounted for 8% of Atlantic sturgeon recaptures. In the past, it was estimated that over 100 shortnose sturgeon were captured annually in shad fisheries in the Delaware River, with an unknown mortality rate (O'Herron and Able 1985). Nearly all captures occurred in the upper Delaware River, upstream of the action area. No recent estimates of captures or mortality of shortnose or Atlantic sturgeon are available. Shortnose and Atlantic sturgeon continue be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to shortnose and Atlantic sturgeon are likely less than they were in the past.

Striped Bass Fishery
Since 1981, the Commission has managed striped bass, from Maine to North Carolina through an ISFMP. The striped bass fishery occurs only in state waters. With the exception of a defined area around Block Island, Rhode Island, federal waters have been closed to the harvest and possession of striped bass since 1990. All states are required to have recreational and commercial size

[22] The program was terminated in February 2012, with the listing of Atlantic sturgeon under the ESA.

limits, recreational creel limits, and commercial quotas. The commercial striped bass fishery is closed in Maine, New Hampshire, and Connecticut, but open in Massachusetts (hook and line only), Rhode Island, New Jersey (hook and line only), Delaware, Maryland, and Virginia. Recreational striped bass fishing occurs all along the U.S. East Coast.

Several states have reported incidental catch of shortnose sturgeon and Atlantic sturgeon during striped bass fishing activities (NMFS (National Marine Fisheries Service) 2011). There are numerous reports of Atlantic sturgeon bycatch in recreational striped bass fishery along the south shore of Long Island, NY. Shortnose sturgeon and Atlantic sturgeon bycatch is occurring in the Delaware Bay and River, but little bycatch mortality has been reported. Unreported mortality may occur.

Data from the Atlantic Coast Sturgeon Tagging Database showed that from 2000-2004, the striped bass fishery accounted for 43 percent of Atlantic sturgeon recaptures (ASSRT 2007). The striped bass-weakfish fishery also had one of the highest bycatch rates of 30 directed fisheries according to NMFS Observer Program data from 1989-2000 (ASSRT 2007).

Fish trap, seine, and channel net fisheries

No information on interactions between Atlantic sturgeon and fish traps, long haul seines, or channel nets is currently available; however, depending on where this gear is set and the mesh size, the potential exists for shortnose sturgeon and Atlantic sturgeon to be entangled or captured in net gear.

State gillnet fisheries

State gillnet fisheries might occur in the action area. However, limited information is available on interactions between these fisheries and protected species. Large and small mesh gillnet fisheries occur in state waters. Based on gear type (i.e., gillnets), it is likely that shortnose sturgeon and Atlantic sturgeon would be vulnerable to capture in these fisheries. Bycatch of a few shortnose sturgeon in the commercial gillnet fishery for shad (fixed and drift gillnets) in the Delaware River has been reported (SSSRT 2010).The majority of reports of Atlantic sturgeon captures during the Atlantic sturgeon reward program have been in drift gillnets and pound nets.

State Trawl Fisheries

Trawl fisheries also occur in state waters. Bottom otter trawls in the Northern shrimp fishery are known to interact with Atlantic sturgeon, but exact numbers are not available (NMFS (National Marine Fisheries Service) 2011). A majority (84 percent) of Atlantic sturgeon bycatch in otter trawls occurs at depths <20 meters, with 90 percent occurring at depths of <30 meters (ASMFC (Atlantic States Marine Fisheries Commission) 2007). During the NEFSC's spring and fall inshore northern shrimp trawl surveys, northern shrimp are most commonly found in tows with depths of >64 meters (ASMFC 2011), which is well below the depths at which most Atlantic sturgeon bycatch occurs. Since these fisheries occur in saline waters, it is highly unlikely that they will capture shortnose sturgeon.

Other trawl fisheries occur in state waters, but information is limited. In these fisheries, the gear may operate along or off the bottom. Atlantic sturgeon have been observed captured on state trawl fisheries from 2009-2018. Top landed species on these trips included, among others, summer flounder, little skate, scup, butterfish, longfin squid, spiny dogfish, smooth dogfish, and bluefish. Information available on interactions between ESA-listed species and these fisheries is incomplete.

State recreational fisheries
Atlantic sturgeon and shortnose sturgeon have been observed captured in state recreational fisheries, yet the total number of interactions that occur annually is unknown. There have been no post-release survival studies for this species. However, we anticipate that sturgeon will likely be released alive, due to the overall hardiness of the species. In addition, almost every year in spring during the American shad fishing season in the Delaware River, the NJ Department of Fish and Wildlife receives reports from hook and line anglers of foul hooked and released shortnose sturgeon in the vicinity of spawning grounds (SSSRT 2010). NMFS also engages in educational outreach efforts on disentanglement, release, and handling and resuscitation of sturgeon.

6.7 Other Impacts of Human Activities in the Action Area

6.7.1 Contaminants and Water Quality

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

Point source discharges (i.e., municipal wastewater, industrial or power plant cooling water or wastewater) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may affect the health of sturgeon populations. The compounds associated with discharges can alter the pH or receiving waters, which may lead to changes in fish behavior, deformations, reduced egg production and survival, as well as mortality.

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

Though water quality in the Delaware River has improved over the last decades following the passage of the CWA, water-borne contaminants are still present in the action area, albeit at reduced levels (Kauffman 2010). Large portions of the Delaware River are bordered by highly industrialized waterfront development. Sewage treatment facilities, refineries, manufacturing plants and power generating facilities all intake and discharge water directly from the Delaware River. This results in large temperature variations and the presence of heavy metals, dioxin, dissolved solids, phenols and hydrocarbons which may alter the pH of in the water that may eventually lead to fish mortality. Industrialized development, especially the presence of refineries, has also resulted in storage and leakage of hazardous material into the Delaware River. One superfund site is located approximately 34 km (21 miles) upstream from the action area at Pedricktown, NJ. Presently 15 Superfund sites have been identified in Delaware and several have yet to be labeled as a Superfund site, but they do contain hazardous waste. Of the 15 sites, eight are in close proximity to the Delaware River or next to tributaries to the Delaware River. EPA has removed two sites at the Deepwater Point Range (RKM 102.2 and 109.4) from the National Priority List (https://www.epa.gov/de/list-superfund-sites-delaware). Contaminants have been detected in Delaware River fish with elevated levels of PCBs in several species. Although difficult to evaluate the effects, it is possible that the presence of contaminants in the action area have adversely affected sturgeon abundance, reproductive success and survival.

Several characteristics of sturgeon life history including long life span, extended residence in estuarine habitats, and being a benthic omnivore, predispose this species to experience bioaccumulation of toxins after long term, repeated exposure to environmental contaminants. (Dadswell 1979). Toxins introduced to the water column become associated with the benthos and can be particularly harmful to fish, such as sturgeon, that feed on benthic organisms (Varanasi 1992). Heavy metals and organochlorine compounds are known to accumulate in fat tissues of sturgeon, but their long-term effects are not yet known (Ruelle and Henry 1992, Ruelle and Keenlyne 1993). Available data suggest that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). Although data on the impacts of contaminants on sturgeon are limited, elevated levels of environmental contaminants, including chlorinated hydrocarbons, in several other fish species have been associated with reproductive impairment (Cameron *et al.* 1992, Longwell *et al.* 1992), reduced egg viability (Hansen *et al.* 1985, Mac and Edsall 1991, Von Westernhagen *et al.* 1981), and reduced survival of larval fish (Berlin *et al.* 1981, Giesy *et al.* 1986). Some researchers have speculated that PCBs may reduce the shortnose sturgeon's resistance to fin rot (Dovel *et al.* 1992).

Although there is scant information available on levels of contaminants in Atlantic sturgeon and shortnose sturgeon tissues, some research on other, related species indicates that concern about effects of contaminants on the health of sturgeon populations is warranted. Detectable levels of chlordane, DDE, DDT, and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (US Fish and Wildlife Service 1993). These compounds may affect physiological processes and impede a fish's ability to withstand stress. PCBs are believed to adversely affect reproduction in pallid sturgeon (Ruelle and Keenlyne 1993). Ruelle and Henry (1992) found a strong correlation between fish weight $r = 0.91$, $p < 0.01$), fish fork length $r = 0.91$, $p < 0.01$), and DDE concentration in pallid sturgeon livers, indicating that DDE concentration increases proportionally with fish size.

Contaminant analysis was conducted on two shortnose sturgeon from the Delaware River in the fall of 2002. Muscle, liver, and gonad tissue were analyzed for contaminants (ERC 2002). Sixteen metals, two semi-volatile compounds, three organochlorine pesticides, one PCB Aroclor, as well as polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans

(PCDFs) were detected in one or more of the tissue samples. Levels of aluminum, cadmium, PCDDs, PCDFs, PCBs and DDE (an organochlorine pesticide) were detected in the “adverse effect” range. It is of particular concern that of the above chemicals, PCDDs, DDE, PCBs and cadmium, were detected as these have been identified as endocrine disrupting chemicals. While no directed studies of chemical contamination in sturgeon in the Delaware River have been undertaken, it is evident that the heavy industrialization of the Delaware River is likely detrimentally impacting the Atlantic sturgeon and shortnose sturgeon populations.

6.7.2 Private and Commercial Vessel Operations

The Delaware River Basin port system is one of the largest in the US (Altiok *et al.* 2012). We have identified 11 major ports with over 39 terminals within the Delaware River. Cargo and tanker vessels calling at these ports travel within the action area on the Philadelphia to the Sea navigation channel. In addition, substantial vessel activity by tugs supporting vessels during docking and departure as well as other port activities (e.g., maintenance dredging of berths and constructions) occur on the river. This vessel traffic overlaps with Atlantic sturgeon distribution within the action area. A high volume of commercial traffic greatly increases the risk of vessel strikes (Fisher 2011, Simpson 2008). Further, high volume of vessel traffic increases the risk of oil spills and leakage (Delaware River and Bay Oil Spill Advisory Committee 2010), which may detrimentally impact Atlantic sturgeon critical habitat as well as the sturgeon individuals.

6.7.3 Vessel Activity

We have reports of vessel interactions with sturgeon 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 and vessel interactions. Vessels may impact listed species through generalized disturbance of essential life behaviors, injury/mortality due to collisions, and through the degradation of habitat (PIANC 2008, Stoschek *et al.* 2014). 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 to shortnose and Atlantic sturgeon.

6.7.3.1 Vessel Activity in the Project Area

The channel between Artificial Island and the federal navigation channel is currently free of a maintained navigation channel and the majority of vessel disturbance is from vessel traffic between the Hope Creek and Salem Stations, and the presence of recreational and fishing vessels. Thus, the river channel between the federal navigation channel and Artificial Island provides a foraging area and a channel for spawning migrations where movement is uninterrupted by maintained vessel infrastructure. This is the case all the way until reaching the16-foot deep Salem River Channel located approximately 3.5 miles upstream of the Port site. In addition, General Anchorage 2 is located next to the Philadelphia to the Sea Navigation Channel at the upstream end of Artificial Island, which may also contribute to vessel activity.

Cargo and tanker vessel movements are restricted to the maintained navigation channel and only tow or tug vessels, fishing vessels, large recreational vessels, and, likely, smaller recreational vessels operate within the Project Area (https://marinecadastre.gov/oceanreports and https://livingatlas.arcgis.com/vessel-traffic). Tugboat traffic between the shoreline of Artificial

Island and the navigation channel is seasonal with the majority occurring during September through March. The shallower draft recreational vessels commonly transect the project area. This activity is also highly seasonal. For example, almost no traffic occurred from December 2019 through March 2020. The OceanReports website, a NOAA/BOEM partnership, provides an online accessible interactive website to explore vessel density in navigational rivers. The GIS based website shows annual vessel activity in different areas of the channel for different vessel types as well as for all vessel types combined. To calculate vessel density, the number of vessels that transect each cell in a grid of 100 m by 100 m cells is calculated using AIS data (Figure 21). By drawing a box in an area of interest, it is possible to calculate the average number of vessels transecting cells within the box (Figure 21). Based on this, in 2019, an average count of 16 (min 1, max 66) tow or tug vessel transits occurred within each cell along Artificial Island outside of the navigation channel. For all vessels (including passenger and fishing vessels) transecting or operating within the Project Area, an average of 65 vessels (min 1, max 185) transected a cell. Based on these data, a relatively low density of vessels operates within the Project Area.

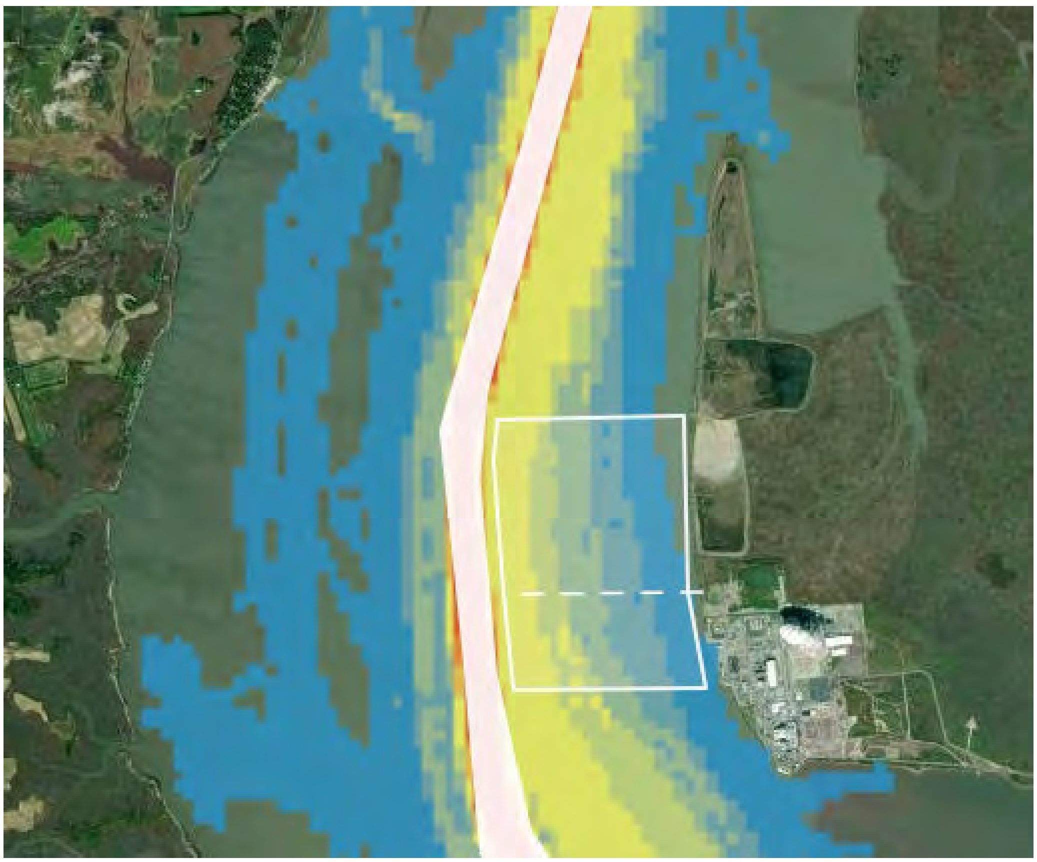

Figure 21. Vessel density in the area (outlined) where project vessels will operate during construction and operation of the proposed NJWP. The stippled line shows the approximate location of the proposed accss channel to the port. Vessel activity is represented as number of vessels transecting each 100 x 100 meter square cell in a grid. Cooler colors (blues) represent fewer vessels with number of vessels in a cell increasing with increasingly warmer cololors. The highest density of vessels occur in the navigation channel but are not visible as the cells are coverd by a polygon for the navigatoin channel.

6.7.3.2 Vessel Activity within the overall Action Area

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 represent 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. (https://www.iwr.usace.army.mil/About/Technical-Centers/WCSC-Waterborne-Commerce-Statistics-Center-2/WCSC-Waterborne-Commerce/). The data includes both self-propelled and non-self-propelled vessels but does not include non-commercial vessels such as recreational vessels. Vessel movements are reported as “trips.” A trip is the movement of a vessel from a starting point to an end point. A vessel trip may be the loading of cargo on a vessel to the offloading site of the cargo or it may be the transport of the working crew to (or from) a work site (e.g., dredging site). Thus, one vessel may have multiple trips during a day as it loads and unloads cargo or transports crew back and forth to a work site. The data includes ferry movements but movements of vessels exclusively engaged in construction (e.g. supporting a dredge) are not included, although movements of supplies and materials to and from a construction site must be reported. Movements of tugboats moving large ships in channels and harbors traveling less than one mile are not reported. Movements of towboats engaged in fleeting activities less than one mile are also not reported. In the spreadsheet, trips are reported as the annual number of trips by vessels of a given draft within a waterway or section of waterway. For this biological opinion, the waterway of interest is the Trenton to the Sea Federal Navigation Channel in the Delaware River (which includes the Philadelphia to Trenton and the Philadelphia to the Sea FNPs).

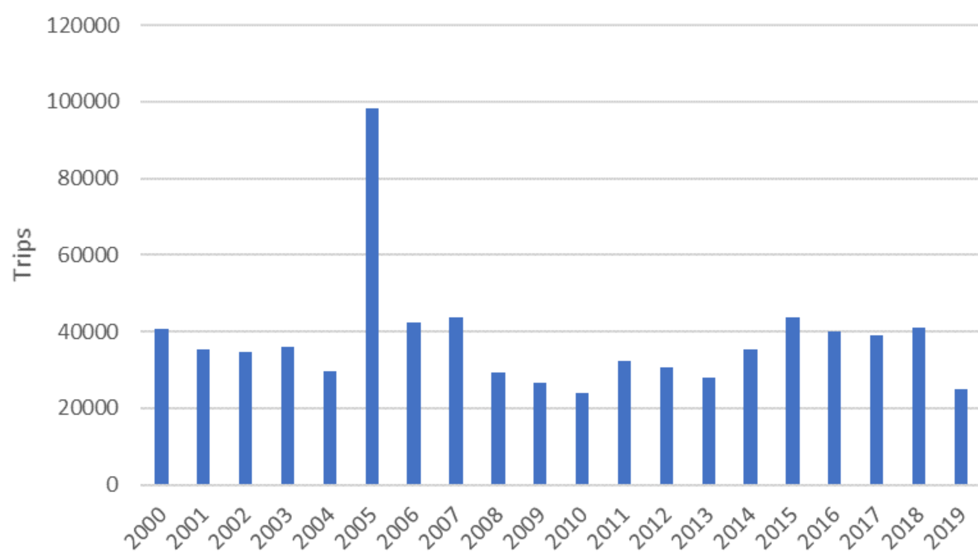

Figure 22. Annual number of trips by self-propelled vessels in the Trenton to the Sea Federal Navigation Channel.

The Waterborne Commerce data available to us includes data from 2000 to 2019. Vessel activity during this period has varied with significant economic trends visible in the number of vessel trips Figure 22. For this analysis, we used data from 2010 to 2019 to characterize the baseline vessel trips in the channel (no obvious trend over the whole 19-year or 10-year period; 2005 appears to be an outlier (Figure 22). The annual number of trips for all vessels (self-propelled and non-self-propelled, all drafts) in the federal navigation channel from Trenton to the sea ranged from 30,853 to 52,032 (median = 41,795) during the period from 2010 through 2019 (Table 28). Based on the observations of vessel strikes and examination of carcasses, entrainment through propellers and contact with the propeller blades appears to pose the greatest risk of injury or mortality (Balazik *et al.* 2012d, Brown and Murphy 2010). Therefore, non-self-propelled vessels likely pose minimal risk of a vessel strike that could injure or kill a sturgeon. Further, self-propelled vessels such as tugboats transport non-self-propelled vessels and, therefore, the self-propelled vessel and the barges they transport is considered one vessel trip and not two. The annual number of only self-propelled vessel trips ranged from 23,925 to 43,754 (median=33,799) with a total of 339,074 trips over the period from 2010 to 2019 (Table 29). Large vessels with deep drafts providing little bottom clearance are likely to pose a greater risk of vessel strike than vessels with a draft that gives more bottom clearance because sturgeon tend to remain near the benthos for most of their time (Balazik *et al.* 2012d, Brown and Murphy 2010). Given that the navigation channel is -45 ft MLLW, that a propeller may draw water from five to six meters below the hull (Maynord 2000), and that a sturgeon may swim a couple of meters above the bottom while moving between foraging spots; we expect that a vessel traveling in the navigation channel would need less than 25 feet of draft (i.e., 6 m or 20 ft clearance) to avoid interacting with a foraging sturgeon. During the same ten-year period, a total of 38,115 up-and-down-bound trips (annual median = 3,848, min=3,380; max=4,268) occurred by self-propelled vessels with a draft of 25 ft or more (Table 30). Figure 23 shows number of vessel trips per year for different vessel types. However, during migration, sturgeon may occur in the water column at the same depth as the draft of a standard tugboat and, thereby, be exposed to the propeller of shallower draft vessels (Balazik *et al.* 2012d, Reine *et al.* 2014).

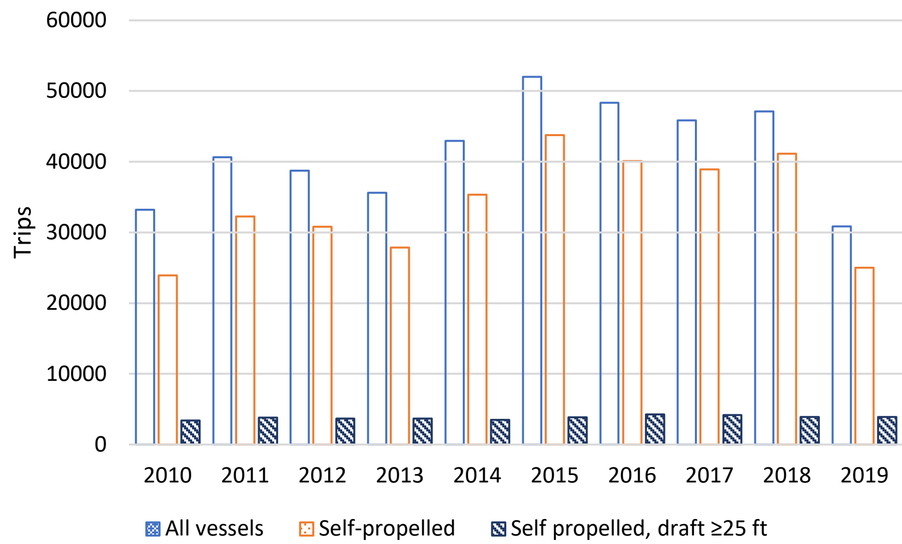

Figure 23. Annual number of Trenton to Sea vessel trips by vessel category (USACE Waterborne Commerce Data 2021)

These numbers represent the best available estimate of vessel traffic within the action area. The estimate excludes recreational vessels, vessels not engaged in movement of cargo, and Department of Defense (DoD) vessels (i.e., USN, USCG, etc.). Therefore, this number likely underestimates the total annual vessel traffic within the Delaware River. There is significant uncertainty in estimating the total amount of non-commercial vessel traffic in the action area. In general, recreational vessel traffic is expected to be seasonal with peak traffic occurring between the Memorial Day and Labor Day holidays (USCG 2012 as cited in NMFS 2017e).

Table 28. Annual number of vessel trips, Trenton to the Sea, for both self-propelled and non-self-propelled vessels. USACE Waterborne Commerce data.

Trip Direction	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	All years
Downbound	18,129	21,582	19,899	19,786	22,653	26,418	24,786	23,336	24,592	15,777	493,109
Upbound	15,099	19,053	18,855	15,806	20,301	25,614	23,536	22,534	22,521	15,076	481,298
Both	**33,228**	**40,635**	**38,754**	**35,592**	**42,954**	**52,032**	**48,322**	**45,870**	**47,113**	**30,853**	**974,407**

Table 29. Annual number of vessel trips, Trenton to the Sea, for self-propelled vessels of all drafts. USACE Waterborne Commerce Data.

Trip Direction	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	All years
Downbound	13,353	17,275	15,769	15,826	18,704	22,085	20,498	19,801	21,524	12,808	381,793
Upbound	10,572	14,983	15,031	12,017	16,636	21,669	19,591	19,124	19,624	12,184	374,304
Both	**23,925**	**32,258**	**30,800**	**27,843**	**35,340**	**43,754**	**40,089**	**38,925**	**41,148**	**24,992**	**756,097**

Table 30. Annual number of vessel trips, Trenton to the Sea, for self-propelled vessels with a draft at 25 feet or deeper. USACE Waterborne Commerce Data.

Trip Direction	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	All Years
Downbound	1,567	1,884	1,758	1,787	1,675	1,858	2,082	1,960	1,843	1,886	35,170
Upbound	1,813	1,944	1,905	1,895	1,798	2,009	2,187	2,194	2,042	2,028	41,220
Both	**3,380**	**3,828**	**3,663**	**3,682**	**3,473**	**3,867**	**4,269**	**4,154**	**3,885**	**3,914**	**76,390**

6.7.3.3 Information on Sturgeon Mortality Resulting from Vessel Strike

As detailed above, the impacts of vessel strikes on sturgeon is a concern, and specifically, lethal strikes resulting in mortality have been documented. 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 identified 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. Brown and Murphy (2010) reported that a majority of mortalities in the River were adult Atlantic sturgeon greater than 150 cm (5 ft) total length with 39% of the mortalities reported being juveniles. The majority (71%) of sturgeon carcasses showed sign of interaction with large commercial vessels with large propellers and deep draft (Brown and Murphy 2010). This corresponds to conclusions drawn from other rivers (Balazik *et al.* 2012d). Brown and Murphy (2010) found that vessel strikes 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 (https://dnrec.alpha.delaware.gov/fish-wildlife/fishing/sturgeon/). The data does not represent a scientific or dedicated survey. All of the sturgeon mortalities are 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 the number of reported carcasses relative to, for instance, yearly differences in vessel activity. Over the period from 2005 through 2019[23], public and state employees reported 237 sturgeon carcasses (data provided by Ian Park, DNREC, 2017). Of these, 217 were identified as Atlantic sturgeon, 13 were identified as shortnose sturgeon, and seven were not identified to species.

Of all sturgeon carcasses reported, 126 showed sign of interaction with boat propellers and 18 were identified as having died by other causes (some of these, e.g., entrapment in dredge, are included in discussions of mortalities caused by other stressors than vessel strike). Cause of death could not be determined for 93 of the carcasses, either because they were too decomposed

[23] 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).

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 had missing heads or consisted of only body parts suggesting that a large propeller mutilated them.

Atlantic sturgeon vessel mortalities

Of the 217 carcasses that DNREC biologists identified as Atlantic sturgeon, 23 were observed outside the Delaware River and Bay and are excluded from the calculations below. Vessel strike was identified as the likely cause of death for 101 of the 194 Atlantic sturgeon carcasses reported in the Delaware River and Bay over the period from 2005 to 2019. Over the 15-year period, the annual number of Atlantic sturgeon vessel mortalities in the Delaware River and Bay ranged from two to 15 (median =5) per year. If the carcasses with undetermined causes of death are included, then the total number of reported carcasses equaled 176 with a range from five to 22 (median = 11) per year. Of the 176 Atlantic sturgeon whose cause of death were reported either as vessel strikes or unknown, 89 (50.6 %) were adults, 2 (1.1%) were sub-adults, 37 (21%) were juveniles, and 48 (27.3%) had no reported life stage.

The majority of Atlantic sturgeon mortalities in the Delaware River and Delaware Bay occurred during spring and early summer (Table 32). Fifty-eight (58%) percent of the Atlantic sturgeon vessel strike and unknown mortalities were reported during May and June. Ninety percent (90.3%) were reported during the months from May through October. We expect more people to be on the river and bay during the warmer months, so it is possible that the low number of reports during winter is reflective of reduced public activity.

Including only those reported as vessel mortalities, the majority (73%) of adult carcasses were reported during May and June while juvenile vessel strike mortalities were more evenly distributed across months (Table 31). The number of reported adult carcasses has the same distribution (69.7% reported in May and June) when both vessel strike mortalities and unknown mortalities are included (Table 32). The highest number (21) of reported carcasses (vessel strike and undetermined mortalities) of undetermined life stages was reported in May with 73 percent reported during May through August (Table 31 and Table 32). Since some carcasses were mutilated and size was estimated on remains, it is possible that some sturgeon reported as adults were sub-adults. Still, despite seasonal bias in reporting rates and possible mischaracterization of life stage, the results agree with findings by others that most Atlantic sturgeon mortalities are adults and that they are at high risk of vessel strike in spring when they move into the river (Balazik *et al.* 2012d, Brown and Murphy 2010, Fisher 2011).

Table 31. Total number and percentage of adults, sub-adults, juveniles, and unknown life-stage vessel strike mortalities reported for each month over the years 2005 to 2019.

Month	Adult	%	Juvenile	%	Subadult		Unknown	%	All	%
January	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
February	0	0.0%	1	5.6%	0	0.0%	0	0.0%	1	1.0%
March	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
April	2	3.2%	1	5.6%	0	0.0%	0	0.0%	3	3.0%
May	26	41.3%	0	0.0%	0	0.0%	8	44.4%	34	33.7%
June	20	31.7%	4	22.2%	0	0.0%	2	11.1%	26	25.7%
July	3	4.8%	4	22.2%	0	0.0%	4	22.2%	11	10.9%
August	4	6.3%	2	11.1%	1	50.0%	2	11.1%	9	8.9%
September	2	3.2%	2	11.1%	0	0.0%	1	5.6%	5	5.0%
October	5	7.9%	3	16.7%	1	50.0%	1	5.6%	10	9.9%
November	1	1.6%	0	0.0%	0	0.0%	0	0.0%	1	1.0%
December	0	0.0%	1	5.6%	0	0.0%	0	0.0%	1	1.0%
All Months	63	100.0%	18	100.0%	2	100.0%	18	100.0%	101	100.0%

Table 32. Total number and percentage of Atlantic sturgeon adults, sub-adults, juveniles, and unknown life-stage considered as vessel strike or unknown mortalities reported for each month over the years 2005 to 2019.

Month	Adult	%	Juvenile	%	Subadult		Unknown	%	All	%
January	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
February	1	1.12%	1	2.70%	0	0.00%	0	0.00%	2	1.14%
March	0	0.00%	2	5.41%	0	0.00%	0	0.00%	2	1.14%
April	2	2.25%	3	8.11%	0	0.00%	3	6.25%	8	4.55%
May	34	38.20%	4	10.81%	0	0.00%	22	45.83%	60	34.09%
June	28	31.46%	9	24.32%	0	0.00%	5	10.42%	42	23.86%
July	4	4.49%	5	13.51%	0	0.00%	9	18.75%	18	10.23%
August	6	6.74%	3	8.11%	1	50.00%	2	4.17%	12	6.82%
September	4	4.49%	3	8.11%	0	0.00%	4	8.33%	11	6.25%
October	8	8.99%	5	13.51%	1	50.00%	3	6.25%	17	9.66%
November	2	2.25%	1	2.70%	0	0.00%	0	0.00%	3	1.70%
December	0	0.00%	1	2.70%	0	0.00%	0	0.00%	1	0.57%
All Months	89	100.00%	37	100.00%	2	100.00%	48	100.00%	176	100.00%

Adjusting Number of Vessel Mortalities

Since it is unlikely that the public and other observers report all mortalities that occur in the Delaware River and Bay, it is likely that the actual number of sturgeon mortalities is greater than the 176 reported. Studies are ongoing to provide accurate reporting estimates and interaction rates of Atlantic sturgeon with vessel traffic. For the purposes of this and past biological opinions we have used a study of sturgeon carcass observations on the James River (Virginia) by Balazik *et al.* (2012d) that found monitoring in the James River documented about one-third of all vessel strike mortalities. However other studies such as from the Delaware State University in partnership with the US Fish and Wildlife Service and DNREC estimate reporting rates varied from 2.0 (spring 2018) to 12.5 (summer and fall 2018) percent with a reporting rate of about 5 percent when they combined the data for all seasons over the two years (2018 and 2019) of the study. As there is substantial uncertainty regarding a precise interaction rate and estimates of carcass observations as well as differences seasonally and other factors such as annual fluctuations in number and type of vessels as well as distribution and abundance of sturgeon temporally and spatially in the rivers, we will continue to assume that the average number of reported vessel strikes in any given year represents one-third of actual mortalities. This estimate will continue to be examined as new research becomes available and may modify the methodology for future ESA consultations. For this BiOp, we estimate the median number of Atlantic sturgeon vessel strike mortalities (juvenile, sub-adult, and adult) within the Delaware River during the 2005 to 2019 period to be three-fold higher than 176, or 528.

Baseline Vessel Strike Risk

Public outreach and social media campaigns have improved public reporting of sturgeon carcasses since 2012 (DNREC 2016), and 2019 is the most recent full year of carcass data available. These data represent the best available information for calculating sturgeon mortalities per vessel trip. During the 2012-2019 period, 123 Atlantic sturgeon carcasses were reported. Of the dead Atlantic sturgeon reported, 60 (47.3%) died from apparent vessel strikes and 18 (14.3%) died from apparent non-vessel related injuries. A cause of death could not be determined for the remaining 45 (38.5%) carcasses. For purposes of this biological opinion, it is conservatively assumed that those mortalities were due to vessel strikes. This is reasonable since most reported sturgeon carcasses are adult, subadult, or larger juvenile Atlantic sturgeon, which have few natural predators, and most other anthropogenic mortalities are reported as such (e.g., capture in dredge). However, some anthropogenic mortalities may not be reported (e.g., sturgeon caught in fishing nets). Over the 8-year period (2012 through 2019), there were 105 carcasses reported that were either considered vessel strike mortalities or for which cause of death was unknown. If considering all of these as vessel strikes, then the median number of vessel strike mortalities of Atlantic sturgeon in the Delaware River per year was 12. By multiplying the number of reported Atlantic sturgeon vessel strikes (including those of unknown cause of mortality) by three based on the study by Balazik *et al.* (2012d), we estimate that about 315 Atlantic sturgeon vessel strikes occurred over the 8-year period or a median of 36 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, recreational vessels typically have a draft of a couple of meters or less, and recreational and fishing vessels have small propeller blades that are unlikely to entrain sturgeon. Thus, the most likely interaction between smaller vessels and sturgeon would be through hull or propeller strike (the moving vessel and propeller hitting the fish), and not entrainment. In that case, the sturgeon would have to be in shallow waters or 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. Recreational vessels often operate at higher speeds, which may 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)).

Since sturgeon remain close to the bottom most of the time (Balazik *et al.* 2012d, Fisher 2011, Reine *et al.* 2014), interaction with a shallow draft vessel could mostly occur in shallow waters or when sturgeon surface. For the vessel to strike a sturgeon, the vessel and the surfacing sturgeon must be at the same spot at the exact same time. Since surfacing constitutes a very small portion of a sturgeon's daily activity (0 to 12 per day, Logan-Chesney *et al.* 2018), we expect that sturgeon exposure to shallow draft vessels are extremely rare and is most likely to occur where vessels travel over reaches with a substantially high number of sturgeon present (e.g., shortnose sturgeon overwintering holes). Conversely, cargo vessels and tugboats have large propellers that entrain large volumes of water and severed sturgeon carcasses have been observed suggesting that most vessel strike mortalities occur when sturgeon are entrained in the water going through the propellers of large vessels (Balazik *et al.* 2012b, Brown and Murphy 2010). Since the propellers on recreational and smaller fishing vessels are too small to entrain a sturgeon in the water going through the propeller, the interaction with sturgeon would only occur if the propeller blades directly strike the sturgeon while transiting over the fish. The probability of a propeller hitting a sturgeon when surfacing, even if the vessel is directly overhead is small because the propeller's surface area is also small. Further, while we do not know the force that would be needed to injure or kill a sturgeon by direct impact, we do assume that a recreational vessel would have to travel at considerable speed for a direct impact by the hull to kill a sturgeon. Therefore, while vessel strike by recreational vessels and small fishing boats have occurred, we expect recreational vessel strike mortalities to be rare in the lower Delaware River estuary and in Delaware Bay. As such, they do not meaningfully contribute to our evaluation of baseline vessel strike risk.

In calculating baseline risk of vessel strike, we only include self-propelled vessels in the Waterborne Commerce vessel trip data. However, vessels of all drafts are included since the propeller of even shallower draft vessels such as tugboats entrain large volumes of water and we do not have sufficient information to set a draft threshold for risk.

The number of vessel trips between Trenton and the mouth of the Delaware Bay during the period from 2012 to 2019 was 282,891. Given this scenario, we estimate the number of sturgeon killed per vessel trip by dividing the estimated number of Atlantic sturgeon vessel mortalities (315) by the number of vessel trips (282,891) over the same period. Thus, each vessel trip killed 0.00111 sturgeon. Put another way, one sturgeon is killed for approximately every 898 vessel trips.

Shortnose sturgeon

Early reports of potential vessel strikes of shortnose sturgeon include 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 blunt force trauma. Though the injury was considered to be caused by interaction with a vessel, this was never confirmed. 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, the pattern of lacerations on the carcass suggested possible vessel interaction. It is unknown if those lacerations were caused pre- or post-mortem.

The DNREC data (2005 to 2019) includes 13 shortnose sturgeon mortalities in the Delaware River. The number or reported mortalities ranged from zero to three shortnose sturgeon per year over the ten-year period. Of the 13 shortnose sturgeon, eight were reported as likely vessel mortalities and five had no cause of death reported. Additionally, three (23%) were adults, three (23%) were juveniles, and no life stage was reported for seven (54%) of the carcasses.

Of the 13 reported carcasses, ten were reported between 2012 and 2019. If we assume that mortalities of unknown cause were vessel strike mortalities and that only about one of three carcasses are reported, then there were approximately 30 shortnose sturgeon vessel strike mortalities in the Delaware River during that eight-year period. With 282,891 vessel trips during the same period, approximately 0.00011 shortnose sturgeon are killed per vessel trip. This equates to one shortnose sturgeon vessel strike mortality occur for every 9,430 vessel trips.

The low number of shortnose sturgeon carcasses reported from the Delaware River basin may be related to a several factors: low number of large fish present in areas with high vessel activity; shortnose sturgeon are less often observed and reported because of their relative (to Atlantic sturgeon) small size: a combination of these two factors; or other unknown factors. However, we do not have data to correct for these uncertainties.

6.7.3.4 Impacts to 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 from the Atlantic Ocean, many oil tankers have drafts exceeding 45 ft because of their cargo. They are required to pay for lightering, where enough oil is pumped off the vessel so it may pass upstream during high tide with the required 2 ft of draft 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 (increased turbidity and TSS) throughout the navigation channel from Trenton to the sea. 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 downstream. In these instances, they may take up the majority of the navigation channel, likely causing sediment disturbance throughout the channel and beyond.

7 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future consequences of global climate change throughout the range of the listed species considered here. Additionally, we present the available information about predicted consequences of climate change in the action area and how those predicted environmental changes may affect listed species. Climate change is relevant to the *Status of the Species*, *Environmental Baseline*, *Effects of the Action*, and *Cumulative Effects* sections of this biological opinion. Therefore, rather than include partial discussions in several sections of this Opinion, we are synthesizing this information into one discussion.

7.1 Background Information on Global Climate Change

In its Sixth Assessment Report (AR6) from 2021, the Intergovernmental Panel on Climate Change (IPCC) found that human activities are estimated to have caused approximately a 1.07°C (likely range 0.8°C to 1.3°C) global surface temperature increase over pre-industrial (1850-1900) levels. For the first time in an IPCC report, assessed future changes in global surface temperature, ocean warming, and sea level were constructed by combining multi-model projections with observational constraints based on past simulated warming, as well as the AR6 assessment of climate sensitivity. Even under a very low greenhouse gas (GHG) emissions scenario, the IPCC predicts that the 1.5°C global warming level is more likely than not going to be exceeded in the near term (2021-2040) (IPCC 2021). Since the 1860s, the Northeast U.S. shelf sea surface temperature (SST) has exhibited an overall warming trend, with the past decade measuring well above the long-term average (and the trend line). Changes in the Gulf Stream, increases in the number of warm core ring formations, and anomalous onshore intrusions of warm salty water are affecting the coastal ocean dynamics with important implications for commercial fisheries and protected species. Annual surface and bottom temperatures in the Gulf of Maine and Georges Bank have trended warmer since the early 1980s. The 2020 seasonal surface temperatures have trended warmer in summer and fall and just slightly warmer than average in the winter and spring throughout New England. The 2020 summer SST were the highest on record in Georges Bank with a heatwave of 4.3°C above the heatwave threshold. Annual surface and bottom temperatures in the Mid-Atlantic Bight have also trended warmer since the early 1980s, and seasonal temperatures have similarly trended warmer (NEFSC 2021a, b).

Model projections of global mean sea level rise (relative to 1995-2014) suggest that the likely global mean sea level rise by 2100 is 0.28-0.55 m under the very low GHG emissions scenario, 0.32-0.62 m under the low GHG emissions scenario, 0.44-0.76 m under the intermediate GHG emissions scenario, and 0.63-1.01 m under the very high GHG emissions scenario (IPCC 2021). It is virtually certain that global mean sea level will continue to rise over the 21st century. The magnitude and rate of rise depends on future emission pathways (IPCC 2021). Temperature increases 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).

Ocean temperatures 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 these waters suggest that this region will warm two to three times faster than the global average; given this, existing projections from the IPCC may be too conservative (Saba *et al.* 2015).

The past few decades have also 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 increased the export of freshwater to the North Atlantic. 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 Greene *et al.* 2008, 2007). 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). This in turn, can have climatic ramifications for the entire world (Greene *et al.* 2008). Changes in salinity and temperature may be the result of changes in the Earth's atmosphere caused by anthropogenic forces (IPCC 2021). Specifically, recent research on the North Atlantic Oscillation (NAO), which impacts climate variability throughout the Northern Hemisphere, has found potential changes in NAO characteristics under future climate change until 2100 (Hanna and Cropper 2017).

Global warming of 1.5°C is projected to shift the ranges of many marine species to higher latitudes and drive the loss of coastal resources. The risk of irreversible loss of many marine and coastal ecosystems increases with global warming, especially at 2°C or higher (high confidence) (IPCC 2018). 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 changes in ice cover, salinity, oxygen levels, and circulation. Changes to the marine ecosystem due to climate change may also result in changes in the distribution and abundance of the prey for protected species.

While predictions are available regarding potential consequences of climate change globally, it is more difficult to assess the potential consequences of climate change on smaller geographic scales, such as in the action area. The consequences of future change will vary greatly in diverse coastal regions in the United States. For example, sea level rise is projected to be worse in low-lying coastal areas where land is sinking (*e.g.*, the Gulf of Mexico) than in areas with higher, rising coastlines (*e.g.*, Alaska) (Jay *et al.* 2018). 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. As climate warms, water temperatures in streams and rivers are likely to increase; this will likely result wide-ranging consequences to aquatic ecosystems. Changes in temperature will be most evident during low flow periods when the water column in waterways is more likely to warm beyond the physiological tolerance of resident species (NAST 2000). Low flow can also impede fish entry into waterways and combined with high temperatures can reduce survival and recruitment in anadromous fish (Jonsson and Jonsson 2009).

Expected consequences of climate change for river systems are wide ranging. 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 (Hulme 2005). Rivers could experience 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). Increased water volume in a warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. 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. Within 50 years, river basins that are impacted by dams or by extensive development will experience greater changes in discharge and water stress than non-impacted, free-flowing rivers (Palmer *et al.* 2008). Given this, a global analysis of the potential consequences of climate change on river basins indicates that large river basins impacted by dams will need a higher level of reactive or proactive management interventions in response to climate change than 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 respond and/or adapt to change. Given the above, under a continually changing environment, maintaining healthy riverine ecosystems will likely require adaptive management strategies (Hulme 2005).

Recent changes in climate conditions are well documented and are predicted to continue (IPCC 2021), increasing the likelihood for consequences to marine and anadromous protected species and their habitats. In marine systems, climate change impacts extend beyond changes in temperature and precipitation to include changes in pH, ocean currents, loss of sea ice, and sea level rise. The increased frequency and intensity of floods, droughts, summer low-flows, and stressful water temperatures already occurring in freshwater rivers and streams used by anadromous species are expected to continue or worsen in many locations. Estuaries may experience changes in habitat quality/quantity and productivity because of changes in freshwater flows, nutrient cycling, sediment delivery, sea level rise, and storm surge.

7.2 Species Specific Information on Climate Change Effects

7.2.1 Shortnose and Atlantic Sturgeon

Shortnose and Atlantic sturgeon have persisted for millions of years and have experienced wide variations in global climate conditions, to which they have successfully adapted. Climate change at historical rates (thousands of years) is not thought to have been a problem for sturgeon species. However, at the current rate of global climate change, future consequences to sturgeon are possible. Shortnose and Atlantic sturgeon spawning occurs in freshwater reaches of rivers because early life stages have little to no tolerance for salinity. However, rising sea level may result in the salt wedge moving upstream in affected rivers, reducing the available spawning habitat. For foraging and physical development, juvenile sturgeon need aquatic habitat with a gradual downstream gradient of 0.5 up to as high as 30 ppt (NMFS 2017b). If the salt wedge moves further upstream, sturgeon rearing habitat could also be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing habitat could shift upstream to compensate for the movement of the salt wedge would be limited. While data indicates that an increase in sea level rise would shift the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the salt wedge. It is uncertain over the long term (which includes the foreseeable future) that shifts in the location of the salt wedge would reduce freshwater spawning or rearing habitat in any measurable way. Although if habitat was restricted or somehow eliminated, productivity or survivability would likely decrease.

The increased rainfall predicted by some models within given areas may increase runoff and scour spawning habitat. Additionally, flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with dissolved oxygen (DO) and temperature. Shortnose and Atlantic sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced over larger expanses, sturgeon may be excluded from some currently occupied habitats.

Increased droughts (and water withdrawal for human use) predicted by some models for certain areas may result in the loss of and access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats to unfavorable conditions. If a river becomes too shallow or flows become intermittent, all sturgeon life stages, including adults, may become susceptible to stranding or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues, such as increased concentrations of pollutants, or insufficient flushing of toxins. Any of the conditions associated with climate change are likely to disrupt river ecology, causing shifts in ecological community structure and the type and abundance of available prey. Additionally, temporal shifts in the cues for spawning migration and spawning, itself, may occur and create scenarios where preferred prey are not sufficiently available for developing sturgeon in their rearing habitat.

Shortnose and Atlantic sturgeon in the action area are most likely to experience the effects of global climate change in warming water temperatures, which could change their range and migratory patterns. Warming temperatures predicted to occur over the next 100 years may result in a northward shift/extension of their range (*i.e.*, into the St. Lawrence River, Canada) while truncating the southern distribution, thus affecting the recruitment and distribution of sturgeon range-wide. In the foreseeable future, gradual increases in SST are expected, but it is unlikely that this expanded range will be observed in the near-term future. If any shift does occur, it is likely to be minimal and thus, it seems unlikely that any increases in temperature will cause significant impacts to shortnose and Atlantic sturgeon or a significant modification to the number of sturgeon likely to be present in the action area over the life of the proposed action. However, even a small increase in temperature can affect DO concentrations. For instance, a one degree change in temperature in the Chesapeake Bay could make parts of Chesapeake Bay inaccessible to sturgeon due to decreased levels of DO (Batiuk *et al.* 2009). Low DO was until recently a problem in the Delaware River, excluding sturgeon from the areas upstream and downstream of Philadelphia during summer months. While conditions has improved, areas with critical low DO still occur occasionally depending on flow and water temperatures. Thus, we expect similar consequences as in the Chesapeake Bay if summer water temperatures in the Delaware River should increase with one degree.

The action area does include spawning grounds for Atlantic sturgeon and sturgeon of both species are migrating through the action area to reach their natal river spawning habitat. Elevated temperatures could modify cues for spawning migration, resulting in an earlier spawning season, and thus, altering the time of year sturgeon may or may not be present within the action area. This may cause an increase or decrease in the number of sturgeon present in the action area. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected), it is not possible to predict how any change in water temperature alone will affect the seasonal movements of sturgeon through the action area.

In addition, changes in water temperature may also alter the forage base and thus, foraging behavior of sturgeon. Any forage species that are temperature-dependent may also shift in distribution as water temperatures warm and cause a shift in the distribution of sturgeon. However, because we do not know the adaptive capacity of these species or how much of a change in temperature would be necessary to cause a shift in the species 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, and they would be able to continue to meet their foraging needs. 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 effects would also be minimal. The greatest potential for effects to forage resources would be if sturgeon shifted spatially or temporally where insufficient forage was available; however, the likelihood of this happening seems low because sturgeon feed on a wide variety of species and in a wide variety of habitats.

Hare *et al.* (2016b) provided a method for assessing the vulnerability of shortnose and Atlantic sturgeon to climate change using the best available information from climate models and what we know of the life history, biology, and habitat use of each species. Based on their comprehensive assessment, Gaichas *et al.* (2016) determined that shortnose and Atlantic sturgeons (all DPSs) are highly vulnerable to climate change. Contributing factors include their low potential to alter their distribution in response to climate change (*e.g.*, spawning locations are specific to a population or DPS within a specific geographic region), and their general exposure to the stressors caused by climate change throughout their range, including in estuarine and marine waters. The determinations are supported by the information of Balazik *et al.* (2010) that suggests individual spawning populations will respond to shifting climate conditions with physiological changes (*e.g.*, variation in growth rate) rather than redistributing to a more southern or northern habitat to maintain their exposure to a consistent temperature regime. The low likelihood of shortnose and Atlantic sturgeon to shift distribution in response to current global climate change will also expose them to climatic consequences on estuarine habitat such as variation in the occurrence and abundance of prey species in currently identified key foraging areas.

Climate factors such as sea level rise, reduced DO, and increased temperatures have the potential to decrease productivity, but the magnitude and interaction of consequences is difficult to assess (Hare *et al.* 2016a). Increasing hypoxia, in combination with increasing temperature, affects juvenile sturgeon metabolism and survival (Secor and Gunderson 1998). A multivariable bioenergetics and survival model predicted that within the Chesapeake Bay, a 1°C increase in Bay-wide temperature reduced suitable habitat for juvenile Atlantic sturgeon by 65% (Niklitschek and Secor 2005). These studies highlight the importance of the availability of water with suitable temperature, salinity and DO; climate conditions that reduce the amount of available habitat with these conditions could reduce the productivity of shortnose and Atlantic sturgeon.

Changes in water availability may also affect the productivity of populations of shortnose and Atlantic sturgeon. In rivers with dams or other barriers that limit access to upstream freshwater reaches, spawning and rearing habitat may be restricted by increased saltwater intrusion; however, no estimates of the impacts of such change are currently available.

7.2.2 Consequences of Climate Change in the Action Area on Shortnose and Atlantic Sturgeon and the Delaware River Critical Habitat Unit

As there is significant uncertainty in the rate and timing of climate change as well as the effects that may be experienced in the action area, predicting the impact of these changes on shortnose and Atlantic sturgeon is difficult. We have analyzed the available information, however, to consider likely impacts to sturgeon and their habitat in the action area. The proposed action under consideration is the construction and operation of the Port and the implementation of a mitigation plan**.** As the Applicant has indicated that the typical life of an offshore wind development is 20 to 25 years, we consider here the likely effects of climate change from now through 2047.

Water availability, either too much or too little, as a result of global climate change is expected to have an effect on the features essential to successful sturgeon spawning and recruitment of offspring to the marine environment (for Atlantic sturgeon). The increased rainfall for certain areas predicted by some models may increase runoff, scour spawning areas, and create flooding events that dislodge early life stages from the substrate where they refuge in the first weeks of life. High freshwater inputs during juvenile development can influence juveniles to move further downriver and, conversely, lower than normal freshwater inputs can influence juveniles to move further upriver potentially exposing the fish to threats they would not typically encounter. Increased number and/or duration of drought events (and water withdrawal for human use) predicted in certain areas by some models may cause loss of and access to spawning, rearing, and foraging habitat. Drought conditions in the spawning season(s) may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all sturgeon life stages, including adults, may become susceptible to stranding or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues including shifting (potentially worsening the resulting effects of) the combined interactions of DO, water temperature, and salinity. Elevated air temperatures can also impact DO levels in the water, particularly in areas of low water depth, low flow, and elevated water temperature. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems affecting DO and temperature. Low DO levels from Wilmington, DE, to Philadelphia, PA, that occurred up until the last decade likely restricted sturgeon use of this reach of the river (Brundage and O'Herron 2009, Brundage and Meadows 1982, Hastings *et al.* 1987). However, improved water quality and increased DO have expanded sturgeon use of the river during the summer with the Marcus Hook area becoming an important area for juvenile rearing and an Atlantic sturgeon spawning ground is located at Chester, PA, downstream from Philadelphia. An increase in water temperature and potential increase in DO could again make this area unfit for sturgeon rearing and spawning.

If sea level rise was great enough to consistently shift the salt wedge far enough upstream, it would likely restrict the range of juvenile sturgeon and may affect the development of these life stages (also affecting Atlantic sturgeon critical habitat PBFs 1, 2, and 4). 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. Dissolved oxygen concentrations between 2005 and 2014 were often in ranges identified as impaired or lethal for Atlantic sturgeon early life stages (Moberg and DeLucia 2016). However, an upstream shift in the salt wedge will have little effect on shortnose sturgeon spawning and egg development as they spawn in the riverine and upper tidal reaches (RKM 214-238) of the Delaware River more than 90 river kilometers (>56 miles) upstream of the current median upper monthly location of the salt wedge.

Atlantic sturgeon spawning and rearing habitat (PBF 1) in the Delaware River are found in the tidal river upstream of the Delaware border (~RKM 125) to Trenton, NJ, (~RKM 214) and there are no impassable falls or manmade barriers that limits upstream access. Based on predicted upriver shifts in the salt wedge, areas specific to where Atlantic sturgeon currently spawn could, over time, become too saline to support spawning and rearing. Recent modeling by NRC 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 upstream. Breece *et al.* (2013) used habitat modeling to consider where adult Atlantic sturgeon would be located under various scenarios including any shifts in the location of the salt front's current location between RKM 108 and 122 due to changes in sea level rise in 2100 (i.e., shift to 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 various drought conditions observed in the 1960s). 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 habitat. Freshwater rearing habitat for Atlantic sturgeon post yolk sac larvae and young juveniles (RKM 125 to 214) is at greater risk from encroaching salt water as some of the best potential rearing habitat occurs at thedownstream end of that range (i.e., Marcus Hook Bar area below Little Tinicum Island). Above Little Tinicum Island (RKM 142), the shorelines on both sides are characterized by industrial and urban development and the river becomes more channelized with little habitat complexity. Thus, the available habitat for juveniles of both sturgeon species could decrease over time and a shift of the salt front several miles upstream could have a significant effect on juvenile sturgeon production. The areas in the Delaware River critical habitat unit containing PBF 2 (aquatic habitat with soft substrate and a gradual downstream salinity gradient of 0.5-30 ppt for juvenile foraging and physiological development) may also shift upstream, but would not necessarily be diminished in size or quality.

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 also be minimal. The greatest potential for effects to forage resources would be if sturgeon shifted spatially or temporally and 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 *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C. In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). Tolerance to temperatures is thought to increase with age and body size (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.* (2017) 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 shortnose sturgeon to be a reasonable surrogate for Atlantic sturgeon given similar geographic distribution and known biological similarities. Mean monthly ambient temperatures in the Delaware estuary range from 11-27°C from April through November, with temperatures lower than 11°C from December-March. As noted above, there are various studies looking at temperature in the Delaware Bay (Moberg and DeLucia 2016). Rising temperatures could meet or exceed the preferred temperature of shortnose and Atlantic sturgeon (28°C) on more days and/or over 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 specific scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data, these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species, which may allow them to deal with change better than predicted. When we designated the Delaware River as critical habitat for the New York Bight DPS of Atlantic sturgeon, we did not extend any areas upstream because of anticipated impacts of climate change. Rather, we determined that the areas designated would accommodate any changes in distribution of the PBFs that may result from climate change over the anticipated 25-year life span of the NJWP.

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

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

8 CONSEQUENCES OF THE ACTION ON SPECIES

8.1 Sound Energy from Pile Driving

The driving and removal of piles generate sound waves that travel through the water body and may affect listed sturgeon species. 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, 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 vibratory and impact pile driving equipment from land and three crane barges with tug support in-water to install 650 30-inch square concrete piles for construction of the quay structure. The two mooring dolphins and one breasting dolphin located at the northern section of the Port will be supported by a total of 34 30-inch square concrete plumb piles and 30-inch square concrete battered piles set at a 3:1 slope. The submerged sheet pile/king pile wall will be constructed to stabilize the Port's shoreline and will consist of a new bulkhead of steel sheet pile and king 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 and material of the piles , installation methods, substrate type where the piles are driven, depth, in-water obstructions, and other factors (Buehler *et al.* 2015). Pile driving may expose aquatic species to sound pressure traveling through the water body resulting in effects ranging from startle response to physiological injury and death. Factors that contribute to the likelihood of an adverse consequence include size, species, 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 with an 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's review of hydroacoustic pressure levels and effects on fish to help inform the analysis[24]. 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.

8.1.1 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 factor of 10 increase in sound pressure, and a 20 dB increase is a 100-fold 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

[24] http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm

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.

8.1.2 Criteria for Assessing the Potential for Physiological Responses

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 ft) 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 8 ft in diameter, whereas Ruggerone *et al.* (2008) found no mortality to caged yearling coho salmon (*Oncorhynchus kisutch*) placed as close as 2 ft from a 1.5-foot diameter pile and exposed to over 1,600 strikes. As noted above, data indicates that species have different tolerances to noise and may exhibit different responses to the same noise source.

Potential physiological effects are highly diverse. Sound exposure that may result in mortality-inducing physiological effects in one species could result in physiological effects that would have no effect on fish survival in another. Potential effects 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 exposed to normal sounds. However, very intense noise, and particularly that with very sharp onset (also called "rise time") will cause the swim bladder walls to move a much greater distance and thereby strike nearby tissues such as the kidney or liver. Rapid and frequent striking (as can occur during one or more sound exposures) may 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, U.S. Fish and Wildlife Service (USFWS), U.S. Federal Highway Administration (FHWA), California Department of Fish and Game, USACE, 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 NMFS, USFWS, FHWA, and the state agencies signed an MOA documenting criteria for assessing physiological effects of pile driving on fish (Molnar *et al.* 2020). 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 (Molnar *et al.* 2020), and not levels at which fish are necessarily mortally damaged. These criteria were developed to apply to all fish 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).

The FHWG developed the interim criteria because resource agencies needed immediate thresholds to guide evaluation of the consequences of pile driving in order to ensure conservative protection of threatened and endangered fish. However, at the time when the FHWG developed the interim criteria, the FHWG recognized that more data and research was necessary to further consider and refine the thresholds. Studies of noise effects on fish do demonstrate that individual species possess different "tolerances" to varying noise sources and that for some species and in unique situations, fish can be exposed to noise levels greater than the FHWG criteria and exhibit little or no negative effects. For instance, recent research summarized in Popper *et al.* (2014) suggests that $SEL_{CUMULATIVE}$ thresholds for injury may be well above 200 dB. Molnar *et al.* (2020) noted that "during the time that has passed since the interim injury thresholds were first established in 2008, there has not been a single documented (in the field or lab studies) instance of even minor injury to fish that have been exposed to sound pressure levels in excess of the $SEL_{CUMULATIVE}$ threshold." However, for different reasons, the FHWG discussions related to modifications of the interim thresholds, though warranted, have not proceeded and the 2008 criteria remain in place. Given this, 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 that individuals are anticipated to completely recover from with no impact to overall 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.

8.1.3 Available Information for Assessing Behavioral Responses

Empirical studies on 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 (e.g., 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) (Brumm and Slabbekoorn 2005), responses demonstrate variability. Thus, it may be difficult to assign a single criterion above which behavioral responses to noise would occur.

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, transport of the sounds through the substrate may result in higher levels of particle motion at greater distances than would be expected from the direct sounds (i.e. through the water or air). Unfortunately, data on particle motion from pile driving is not available at this time, and we must 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 Exposure to Increased Underwater Noise

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

In-water pile driving for the construction of the wharf, mooring dolphins, and the protective wall will occur over several periods between September through December 2022 and January through February 2023. Each period will span approximately 40 to 80 days of pile driving. Upland pile driving will occur form May 2022 to January 2023 and from July to December 2023.

Based on this schedule, in-water pile driving will occur outside of the sturgeon spawning period, and adult Atlantic sturgeon will not be exposed to sound from pile driving during spawning migrations. However, adults, especially males, may move downstream as late as October. Further, adults of both sexes as well as subadults may reside in the lower estuary from summer and into November. Therefore based on this schedule, pile driving can expose adult and subadult Atlantic sturgeon to elevated noise. 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 as well as adult shortnose sturgeon occur in the low salinity tidal reaches of the river. Water depth at the project site is generally 6 m (20 ft) at MLLW and is deeper during high tide. Both species generally occur at depths of 6 m and deeper but are also found in shallower areas. In October 2020, benthic grabs were collected at 24 sites for sediment and benthic invertebrate analysis and benthic invertebrates were present in 17 samples, therefore, 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 Area.

To estimate pile driving sound levels at different distances during construction, we primarily 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 could affect sturgeon (Molnar *et al.* 2020).

We used the acoustic tool developed by our office (GARFO Acoustic Tool) that uses proxy projects to assist in estimating the ensonified area for piles of different types and sizes, driven with different hammers, and with different attenuations[25]. The GARFO tool also provides a Simplified Attenuation Formula (SAF) that was developed 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 the "Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish" (Technical Guidance) prepared for Caltrans in 2009 (last amended in 2020) (Molnar *et al.* 2020). If Caltrans did not include a clear attenuation estimate, the GARFO Acoustic Tool 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). For this Opinion, we use the GARFO acoustic tool and the SAF to estimate intensity and spatial extent of sound levels to analyze the consequences of the proposed pile driving because of the location of the Port in the river (summarized in Tables below).

To attenuate noise levels from pile driving by impact hammer, 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

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

was highly variable, and because they can splinter or break. Because the effect of a wood cushion caps varies, the GARFO acoustic tool uses the lower end (-11 dB) of measured attenuation in estimating the potential for pile driving exceeding injurious peak noise levels. Based on the use 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.

Table 33 and Table 34 provide estimated sound levels and distance from piles where injury and behavioral effects would occur for the 30-inch diameter concrete piles and sheet piles, respectively. The Technical Guidance does not include hydroacoustic monitoring result for a 30-inch diameter concrete pile. Based on comparison of concrete piles and steel piles of similar size, we expect that pile driving of steel piles will result in equal or higher sound levels. Therefore, we use results for a 30-inch dimeter steel pile and a 24-inch diameter concrete pile as proxy projects to explore a range of potential sound levels during pile driving and to estimate a worst-case scenario. For the steel sheet piles, we use sound monitoring for standard 24-inch size sheet piles as proxy projects to estimate driving of sheet piles for the bulkhead.

Table 33. Estimated intensity and extent of underwater noise for a 30-inch concrete pile based on proxy projects. a) Proxy projects and piles for estimating underwater noise. b) Proxy-based estimates for underwater noise. c) Estimated distances to sturgeon injury and behavioral thresholds.

a. Proxy Project

Proxy	Project Location	Water Depth (m)	Pile Size (inches)	Pile Type	Hammer Type	Attenuation rate (dB/10m)
A	Florence, OR - Siuslaw River	3	30	Steel Pipe	Cushioned Impact	5
B	San Rafael, CA - San Francisco Bay	4-5	30	Steel Pipe	Cushioned Impact	5
C	Not available	3-4	24	Concrete	Impact	5

b. Underwater Noise

Proxy	Type of Pile	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})
A	30-inch Steel Pipe	199	179	166
B	30-inch Steel Pipe	194	189	169
C	24-inch Concrete	188	176	166

c. Distance to Injury and Behavioral Threshold

Proxy	Distance (m) to 206dBPeak (injury)	Distance (m) to 150 dBsSEL (surrogate for 187 dBcSEL injury)	Distance (m) to Behavioral Disturbance Threshold (150 dBRMS)
A	0	42.0	68.0
B	0	48.0	88.0
C	0	42.0	62.0

Table 34. Estimated intensity and extent of underwater noise for a sheet piles. a) Proxy projects and piles for estimating underwater noise. b) Proxy-based estimates for underwater noise. c) Estimated distances to sturgeon injury and behavioral thresholds.

a. Proxy Project

Proxy	Project Location	Water Depth (m)	Pile Size (inches)	Pile Type	Hammer Type	Attenuation rate (dB/10m)
A	Not Available	15	24	AZ Steel Sheet	Impact	5
B	Not Available	15	24	AZ Steel Sheet	Vibratory	5

b. Underwater Noise

Proxy	Type of Pile	Estimated Peak Noise Level (dB_{Peak})	Estimated Pressure Level (dB_{RMS})	Estimated Single Strike Sound Exposure Level (dB_{sSEL})
A	24-inch AZ Steel Sheet	205	190	180
B	24-inch AZ Steel Sheet	182	165	165

c. Distance to Injury and Behavioral Threshold

Proxy	Distance (m) to 206dBPeak (injury)	Distance (m) to 150 dBsSEL (surrogate for 187 dBcSEL injury)	Distance (m) to Behavioral Disturbance Threshold (150 dBRMS)
A	8	70.0	90.0
B	0	40.0	40.0

Based on the data above, driving (with the proposed cushion) of concrete and steel pipe piles will not result in peak sound levels above 206 dB. Thus, there is no potential for physiological effects due to exposure to peak noise levels during construction of the construction of the quay structure, two mooring dolphins, and one breasting dolphin. Based on sound measured at a 10-meter distance from the pile, peak sound level reached injury levels for 24-inch steel sheet piles may occur when driven by impact hammer (Table 34c). Only piles driven with impact hammer would be expected to generate peak sound pressure levels above 206 dB re 1 µPa at water depths of 15 m, which is deeper than the approximate water depths at the proposed depth of approximately 10 m at the terminal site once dredging is completed. An area within a distance of 90 meters from the shoreline will have peak sound pressure levels over 206 dB. However, the proposed pile driving will also use a vibratory hammer to drive piles 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.

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.[26] 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.

Using the information from proxy projects and reducing the sSEL with 11dB attenuation from use of cushion block, we estimated the distances of 150 dB sSEL during impact driving. The distance for the proxy projects ranged from 42 m (138 ft) for the 24-inch concrete pile (no cushion) to 48 m (158 ft) for a 30-inch steel pipe piles (with cushion). Sturgeon that remain within a distance up to 48 m of concrete or king piles during construction of the quay structure, two mooring dolphins, and one breasting dolphin will be exposed to injurious levels of noise during installation of the piles. During construction of the new sheet pile bulkhead, sturgeon that remain within a distance up to 70 m (230 ft) of a 24-inch concrete pile driven by an impact hammer will be exposed to injurious levels of noise during installation of the piles. It should be noted that the risk of injury decreases with distance from the pile and a sturgeon farther from a pile receives less energy over a given time period than a fish close to a pile.

8.1.5 Sturgeon Response to Proposed Pile Driving

It is reasonable to assume that sturgeon, on hearing pile driving, will either not approach the source or will move around it. Sturgeon in the area are expected to leave the area when pile driving begins, 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.

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 (NMFS 2017c). Thus, we expect the sturgeon to avoid an ensonified area upon exposure to underwater noise levels of 150 dB_{RMS}, if fish do not completely leave after the warning strikes Behavioral modification (avoidance) is expected 88 and 90 m (289 to 295 ft) depending on piles being driven and depth. Even if a sturgeon is within the ensonified area of 150 dB sSEL 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 are for the 24-inch steel sheet piles. Assuming pile driving times for a sheetpile of approximately fifteen minutes; a sturgeon would need to swim at least 70 m before

[26] 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.

the fifteen minute pile driving time was completed, requiring a swim speed of approximately 0.08 m per second (m/s) in order to leave the ensonified area. For a 30-inch concrete pile, a sturgeon would have to swim at a speed of 0.013 m/s to leave the area where accumulated injury could occur. Deslauriers and Kieffer (2012b) measured sustained swimming speed (swimming against a current for 200 minutes) for YOY shortnose sturgeon to 0.18 m/s (0.18 m/s). Further, shortnose sturgeon YOY can 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 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 any ensonified areas in time to avoid injury.

The cSEL 187 dB re 1µPa^2-s area never occupies the entire width of the river; therefore, fish will always be able to move away from an area while pile driving is ongoing. As such, we do not expect sturgeon to remain close enough to a pile during installation with an impact hammer for long enough to accumulate enough energy to be injured. Further, the use of a reduced energy "soft start"[27] technique would help ensure that sturgeon are exposed to reduced noise levels for several minutes before the maximum noise levels are reached. As proposed, a vibratory hammer will be used for the majority of sheetpile driving. The distance that sturgeon must move to avoid injury is substantially shorter for vibratory hammers than impact hammers. We expect this to cause sturgeon close to active pile driving to move further away, thereby reducing the potential for exposure to noise levels that may be injurious or fatal. Thus, any sturgeon present in the area during the start of pile driving are expected to leave the area and not be close to any pile driving activity for long enough to experience injuries or mortality. While sturgeon in the action area will be temporarily exposed to noise levels before 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 cause physiological effects (*e.g.*, low DO, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon will also readily avoid any areas with noise levels that could result in physiological stress or injury. The only way that a sturgeon could be exposed to injurious or fatal noise levels is if a fish is immediately adjacent to a sheetpile while full strength pile driving is ongoing. Because soft start techniques will be used and the expected behavioral response of fish is to move away from the piles being installed, it is extremely unlikely that sturgeon will be exposed to high noise levels for long enough to cause injury.

8.1.6 Physiological Consequences

As described above, we do not expect driving of 30-inch concrete and king piles to produce injurious peak sound levels (≥206 dBpeak). Thus, construction of the quay, dolphins, and

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[27] 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.

protective wall will not expose sturgeon to injurious peak dB levels. We do expect that pile-driving of sheetpiles with an impact hammer will result in injurious peak sound levels up to eight meters from the pile. However, sturgeon are likely to respond to noise during the soft start by moving away from the piles, therefore, sturgeon will not be exposed to injurious peak dB levels. Exposure to pile driving noise below 206 dBpeak can cause injury if the sturgeon is exposed to the noise over a long enough period of time. However, based on the above, we expect that any sturgeon present during the start of pile driving will move out of the ensonified area before the short-term exposure is likely to result in injuries. We also expect sturgeon will not enter the ensonfied area once pile driving has begun. Given the previously stated information, we have determined that pile driving is extremely unlikely to cause injury to shortnose sturgeon or Atlantic sturgeon.

8.1.7 Consequences of Behavioral Modifications

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 by moving out of or avoiding the ensonified area. Available information suggests that the potential for behavioral shifts may begin upon exposure to noise at levels of 150 dB re 1 µPa RMS.

When considering the potential for behavioral consequences, 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 occur.

Depending on the pile size being driven, the 150 dB re 1 µPa RMS isopleth (radius) could extend from 88 to 90 m (289 to 295 ft) from the piles being driven. Shortnose sturgeon and Atlantic sturgeon are likely to be foraging (where forage is present), resting, or migrating up or downstream in the area where piles are being installed. We consider two scenarios here; (1) sturgeon near the pile being installed 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 outside of the area where noise is greater than 150 dB re 1µPa RMS at the onset of pile driving would need to 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 move away from the ensonified area and have their foraging, resting or migrating behaviors disrupted. Even at a slow prolonged speed of 0.18 m/s, all sturgeon would be able to swim out of the area where noise is 150 dB re 1uPa RMS within 10 minutes. Thus, any disruption to normal behaviors are expect to last for no longer than 10 minutes. Foraging is expected to resume as soon as sturgeon leave the area. Resting and migration can also continue as soon as the individual has moved away from the disturbing level of noise. It is unlikely that a short-term (in the worst case scenario of no more than 10 minutes, and generally much shorter) disruption of foraging, resting or migrating will have any impact on the health of an 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 consequences.

Pile driving will never occur for more than 12 hours a day but in the worst case scenario, fish are expected to avoid the ensonified area (i.e., the Port site portion of the action area) for the entirety of the pile driving period, as previously detailed. The Delaware River at the Port location is approximately 3.55 km (2.2 mi) wide from the New Jersey bank to the Delaware bank. The concrete quay structure will extend 17.4 m (57 ft) landward with the new bulkhead being located at the current shoreline. Thus, the behavioral disturbance in the ensonified area will extend a maximum of 90 m (295 ft) into the channel. At all times, there will be at least 3,446 m (~11,352 ft) of the river width free of pile driving generated noise levels greater than 150 dB re 1uPa RMS. Therefore, it is likely that any sturgeon not near the piles at the beginning of installation, will be able to completely avoid the area where noise levels exceed 150 dB re 1uPa RMS. Assuming sturgeon avoid areas with underwater noise greater than 150 dB re 1 µPa during pile driving activities, there will still always be enough space for fish to pass unimpeded in the waterway.

Pile driving activities may cause sturgeon near the construction activities to move into the navigation channel, where there is an increased risk of interaction with vessels. The proposed berth construction activities are located approximately 2,000 m (6,600 ft) from the Federal navigation channel. Since noise levels that would result in behavioral modifications will not extend farther than 90 m from the shoreline, noise levels will not extend near the Federal Navigation Channel. Therefore, there is ample clearance to avoid areas with elevated noise without entering the navigation channel. Further, time of year restrictions for in-water work ensures that adult sturgeon will not be migrating through the construction area to the spawning grounds during 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 essential behaviors such as resting, foraging or migrating and/or affect the fitness of any individuals. Additionally, we do not expect any increase in energy expenditure that has any detectable consequences to the physiology of any individuals or any future consequences to growth, reproduction, or general health. Thus, consequences are too small to be meaningfully measured, detected, or evaluated and, therefore, consequences are insignificant.

8.2 Dredging Entrapment

The scope of the proposed action includes the dredging of the berth, turning basin, and access channel as well as ten years of maintenance dredging. The USACE expects the initial dredging to construct the access channel, turning basin and berths, to occur over a two-year period. Dredging is expected to take three to four weeks and occur during the months of July to September each year for two years. The Applicant has informed the USACE that they will dredge approximately 1,790,000 CY of material from approximately 82 acres within the Delaware River channel (they will also mechanically dredge/excavate an additional 170,000 CY from 4.1 acres landward of the current shoreline). The Applicant will use a hydraulic cutterhead dredge for most of the dredging, but will also use a mechanical dredge to deepen the berth area and to remove material landward of the existing timber bulkhead.

Based on previous dredging at the adjacent Salem and Hope Creek Generating Stations, the Applicant anticipates that maintenance dredging will need to occur two to three times over a ten-year period. Based on information in the BA, we estimate that approximately 500,000 CY of clean sand will be removed during each maintenance event. Therefore, over the 10-year permit (until 2032), we anticipate that approximately 1,500,000 CY of material will be dredged to maintain the access channel, turning basin, and berths. For the 25-year lifetime of the Port (until 2049), maintenance dredging will remove up to 2,500,000 CY of material. We expect that all maintenance dredging will be completed with a hydraulic cutterhead dredge. Thus, initial and maintenance dredging will dredge up to 4,290,000 CY of bottom sediment by the means of cutterhead dredging.

8.2.1 Hydraulic Cutterhead Dredge

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

As noted above, a 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). With a cutterhead dredge, material is pumped directly from the dredged area to a disposal site. As such, there is no opportunity to monitor for biological material on board the dredge; rather, observers work at the disposal site to inspect material for evidence of interactions with listed species.

It is generally assumed that sturgeon are mobile enough to avoid the suction of an oncoming cutterhead dredge and that any sturgeon (with the exception of eggs and immobile larvae) in the vicinity of such an operation would be able to avoid the intake and escape. However, in mid-March 1996, two shortnose sturgeon were found in a dredge discharge pool on Money Island, near Newbold Island in the upper Delaware River. The dead sturgeon were found on the side of the spoil area into which the hydraulic pipeline dredge was pumping. An assessment of the condition of the fish indicated that the fish were likely alive and in good condition prior to entrainment and that they were both adult females. The area where dredging was occurring was a known overwintering area for shortnose sturgeon and large numbers of shortnose sturgeon were known to be concentrated in the general area. A total of 509,946 CY were dredged between Florence and the upper end of Newbold Island during this dredge cycle. Since that time, dredging occurring in the winter months in the Newbold – Kinkora range of the Delaware River required that inspectors conduct daily inspections of the dredge spoil area in an attempt to detect the presence of any sturgeon. In January 1998, three shortnose sturgeon carcasses were discovered in the Money Island Disposal Area. The sturgeon were found on three separate dates: January 6, January 12, and January 13. Dredging was being conducted in the Kinkora and Florence ranges at this time, which also overlaps with the shortnose sturgeon overwintering area. A total of 512,923 CY of material was dredged between Florence and upper Newbold Island during that dredge cycle. While it is possible that not all shortnose sturgeon killed during dredging operations were observed at the dredge disposal pool, USACE has indicated that due to flow patterns in the pool, it is expected that all large material (i.e., sturgeon, logs etc.) will move towards the edges of the pool and be readily observable. Thus, the two dredging cycles captured on average one sturgeon per 204,500 CY dredged. Monitoring of dredge disposal areas used for deepening of the Delaware River with a cutterhead dredge has occurred. Dredging in Reach C took place from March – August 2010 with 3,594,963 CY of material removed with a cutterhead dredge. Dredging in Reach B occurred in November and December 2011, with 1,100,000 CY of material removed with a cutterhead dredge. In both cases, the dredge disposal area was inspected daily for the presence of sturgeon. No sturgeon were detected.

Several studies aimed at understanding dredge interactions with Atlantic sturgeon and shortnose sturgeon exist. The USACE worked with sturgeon researchers in to track the movements of tagged juvenile Atlantic and shortnose sturgeon to understand their behavior while cutterhead dredge operations were ongoing in Reach B of the Delaware River Philadelphia to the Sea Federal Navigation Channel. The movements of 19 acoustically tagged sturgeon were monitored using both passive and active methods (ERC 2012). Three of the juvenile sturgeon detected during this study (two Atlantic sturgeons and one shortnose sturgeon) appeared to have moved through Reach B when the dredge was working. The patterns and rates of movement of these fish indicated nothing to suggest that their behavior was affected by dredge operation. The other sturgeon that were detected in the lower portion of the study area either moved through the area before or after the dredging period (two Atlantic sturgeon), moved through Reach B when the dredge was shut down (three Atlantic sturgeon), or moved through the channel on the east side of Cherry Island Flats (one shortnose sturgeon and one Atlantic sturgeon) opposite the main navigation channel. It is unknown whether some of these fish chose behaviors (routes or timing of movement) that kept them from the immediate vicinity of the operating dredge. In the report, ERC (2012) concluded that this could either be to avoid the noisy area near the dredge or that the movements of the sturgeon relative to dredge operation could simply have been coincidence.

Reine *et al.* (2014) implanted five subadult Atlantic sturgeon (TL = 77.5- 100 cm) in James River, Virginia, with both active and passive transmitters, released the fish in the immediate vicinity of the dredge, and tracked them continuously for several days. Based on the movement of the fish, Reine *et al.* (2014) concluded that: tagged fish showed no signs of impeded up- or downriver movement due to the physical presence of the dredge; fish were actively tracked freely moving past the dredge during full production mode; fish showed no signs of avoidance response (e.g., due to noise generated by the dredge) as indicated by the amount of time spent in close proximity to the dredge after release (3.5 – 21.5 hours); and, tagged fish showed no evidence of attraction to the dredge.

(Balazik *et al.* 2020) also studied the movement of Atlantic sturgeon near an operating cutterhead dredge in the James River in Virginia. The analysis showed that dredging in the lower James River does not create a barrier for adult Atlantic sturgeon migrating to spawning habitat or cause adults to significantly modify swim behavior. The results showed that adult and subadult Atlantic sturgeon were are able to and freely swim past the operating dredge during their estuarine migrations and no incidents of entrainment occurred (Balazik *et al.* 2020).

Several scientific studies aimed at understanding the ability of sturgeon to avoid being entrained in the intake of cutterhead dredges have been undertaken. 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/s (0.33-3.0 fps). Based on the known intake velocities of several sizes of cutterhead dredges, they concluded that at distances of more than 1.5 m 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 immediately adjacent of the drag head and be unaffected by associated disturbance (e.g., turbidity and noise). The authors also conclude that juvenile sturgeon are only at risk of entrainment in a cutterhead dredge if they are in close proximity, less than one meter, to the cutterhead.

Boysen and Hoover (2009) assessed the probability of entrainment of juvenile white sturgeon by evaluating swimming performance of YOY fish (8-10 cm TL). The authors determined that within one meter of an operating dredge head, all fish would escape when the pipe was 61 cm (2 ft) or smaller. Fish larger than 9.3 cm (about 4 inches) are able to avoid the intake when the pipe was as large as 66 cm (2.2 ft). 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 m of the dredge head; beyond that distance, velocities decrease to less than 1 fps.

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

8.2.1.2 Predicted Entrainment of sturgeon in a cutterhead dredge

The risk of an individual sturgeon being entrained in a cutterhead dredge is difficult to calculate. Several factors contribute to making the prediction process challenging. First, while a large area will be dredged, the dredge head itself operates in an extremely small area at any given time (i.e., the river or ocean bottom where the head is placed). Second, to be entrained, an individual fish would need to be extremely close to the where the dredge head is operating (i.e., within one meter of the dredge head) and unable or unwilling to move as the dredge head approaches. In addition, the location of the proposed dredging is not in overwintering habitat where sturgeon aggregate in high densities. In consideration of these factors, the overall risk of entrainment is low. Although the tracking studies in the James and Delaware Rivers show that dredging operations do not affect sturgeon behavior[28], they also demonstrate the sturgeon are not attracted to the dredging equipment. Therefore, it is unlikely that sturgeon in the action area would occur within one meter of the dredge based on past observations. The tracking study data from the

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[28] The studies analyzed behavior (change in direction of migrating fish or changes in distribution in response to the presence of an operating dredge) of sturgeon in the general vicinity of cutterhead dredges and not the fine scale response of sturgeon when a dredge head is approaching within a few meters of the fish.

James and Delaware River supports this, as the studies show that none of the tagged sturgeon were attracted to or entrained in the operating dredges.

However, while the risk of entrainment is low, it cannot be completely discounted when sturgeon are present during dredging operations. The entrainment of five sturgeon in the upper Delaware River indicates that entrainment of sturgeon in cutterhead dredges is possible under certain circumstances. Several factors may increasee the risk of entrainment in that area of the river, but are not present in the areas where cutterhead dredging will occur during the proposed action. For example, all five entrainments occurred during the winter months in an area where shortnose sturgeon are known to concentrate in dense aggregations; sturgeon in these aggregations rest on the bottom and exhibit little movement and may be slow to respond to stimuli such as an oncoming dredge. Although these exact conditions are not present at the Port site, the site does provide high quality forage habitat and both Atlantic sturgeon and shortnose sturgeon are present year round with higher concentration in fall, which coincides with when dredging may occur.

Because the records of Atlantic or shortnose sturgeon entrained in cutterhead dredges in the United States has been limited to the five shortnose sturgeon found at the disposal site in the upper Delaware River, as mentioned above, it is difficult to predict the number of sturgeon that are likely to be entrained during cutterhead dredging in the action area. Based on the available information presented here, entrainment in a cutterhead dredge is likely to be rare - only occurring if a sturgeon is within one meter of the dredge head – and in locations where sturgeon concentrations are higher at certain times of the year. However, because we know that entrainment is possible with five sturgeon entrained during dredging of 1,022,869 CY, that a large number of shortnose sturgeon and Atlantic sturgeon can be present within the area that will be dredged, and because of the relatively large volume (4,290,000 CY – initial and maintenance dredging combined) that will be dredged within an 82-acre area; we expect that over the project life considered here, some entrainment with a cutterhead dredge will occur. Based on the entrainment of one sturgeon per 205,000 CY dredged in the upper Delaware River while also considering the predicted rarity of the entrainment event, we expect that the proposed initial and maintenance cutterhead dredging may entrain up to two sturgeon (either shortnose sturgeon, Atlantic sturgeon, or one of each). The shortnose sturgeon would be either juvenile or adult (section 2.2.1). We expect that subadult and adult Atlantic sturgeon would be able to avoid entrainment in the cutterhead intake because of their large size and strong swimming abilities. However, juvenile Atlantic sturgeon are present year round with higher concentrations in fall and winter when dredging may occur (in-water work window is from July 1 to March 15 the following year). Because of their smaller size, any Atlantic sturgeon entrained in the cutterhead will most likely be juvenile fish. We expect that entrainment through the cutterhead, transport through the pipe, and residency period in the disposal area will kill any entrained sturgeon. Since the majority of the Atlantic sturgeon at the project site will be juveniles and the larger subadult and adult Atlantic sturgeon are likely to avoid entrainment in the water flowing into the cutterhead, we expect that any entrained Atlantic sturgeon will originate from the New York Bight DPS.

Summary of consequences

The initial dredging (2022 and 2023) and maintenance dredging during the 10-year USACE permit (until 2032) will kill two sturgeon. The killed fish will be either shortnose sturgeon, Atlantic sturgeon, or one of each.

- Shortnose sturgeon mortalities will be either juvenile(s), adult(s) or one of either.
- Atlantic sturgeon mortalities will be juvenile fish. All NYB DPS.

8.2.2 Mechanical Dredge

Mechanical dredging entails lowering the open bucket or clamshell through the water column, closing the bucket after impact on the bottom, lifting the bucket up through the water column, and emptying the bucket into a barge. The bucket operates without suction or hydraulic intake, moves relatively slowly through the water column and affects only a small area of the aquatic bottom at any time. In order to be captured in a dredge bucket, an animal must be on the bottom directly below the dredge bucket as it contacts the substrate and remain stationary as the bucket closes. Species captured in dredge buckets can be injured or killed if entrapped in the bucket or buried in sediment during dredging and/or when sediment is deposited into the dredge scow. Species captured and emptied out of the bucket can suffer stress or injury, which can lead to mortality.

8.2.2.1 Mechanical Dredging Consequences on Sturgeon

In 2012, the USACE provided us with a list of all documented interactions between dredges and sturgeon reported along the U.S. East Coast; reports dated as far back as 1990. The list includes five incidents of sturgeon captured in dredge buckets. These include the capture of a decomposed Atlantic sturgeon in Wilmington Harbor in 2001. The condition of this fish indicated it was not killed during the dredging operation and was likely dead on the bottom or in the water column and merely scooped up by the dredge bucket. Another record was the reported lethal capture of an Atlantic sturgeon in Wilmington Harbor in 1998; however, this record was never verified. An Atlantic sturgeon was captured in a clamshell bucket, deposited in the dredge scow, and released apparently unharmed during dredging operations at Bath Iron Works (BIW) in 2001. On April 30, 2003, a shortnose sturgeon was captured in a clam-shell bucket dredge operating in the BIW sinking basin; the fish was nearly cut in half. This fish was killed during the last hour of a 24-hour a day dredging operation that had been ongoing for approximately six weeks. One shortnose sturgeon was captured in a clamshell bucket and detected in the dredge scow on June 1, 2009, during dredging operations at BIW. Observer coverage at dredging operations at the BIW facility has been 100 percent for approximately 20 years, with dredging occurring every one to two years.

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

We expect the risk of interactions between sturgeon and mechanical dredges to be highest in areas where large numbers of sturgeon are known to aggregate. The behavior of sturgeon in the area may also affect the risk of capture. While foraging, sturgeon are at the bottom of the river interacting with the sediment. This behavior may increase the susceptibility of capture with a dredge bucket. We also expect the risk of capture to be higher in areas where sturgeon are overwintering in dense aggregations as overwintering sturgeon may be less responsive to stimuli which could reduce the potential for a sturgeon to avoid an oncoming dredge bucket. The area to be mechanically dredged is not a known overwintering aggregation site for sturgeon.

Most mobile organisms, including adult and subadult Atlantic sturgeon, are able to avoid mechanical dredge buckets. For a bucket dredge to capture a sturgeon, the sturgeon has to be immediately below the bucket and remain stationary as the bucket jaw closes. The slow movement of the dredge bucket through the water column and the relatively small area of bottom impacted by each pass of the bucket makes the likelihood of interaction between a dredge bucket and an individual fish unlikely. Based on all available evidence, the risk that a mechanical dredge will capture a subadult or adult sturgeon is low. Thus, entrapment from a mechanical dredge is extremely unlikely to occur.

8.3 Interaction with Suspended Sediment

Dredging suspends sediment into the water column. Resuspension of sediment may increase total suspended sediment (TSS) load and turbidity above ambient baseline levels. Turbidity relates to the optical quality of light transmission through a fluid containing sediment particles (most often measured as nephelometric turbidity units) and TSS concentration is the gravimetric measure of particles in suspension (generally measured as milligrams per liter (ml/L).

High concentration of suspended sediment or turbidity may affect fish through many pathways (Johnson 2018, Kjelland *et al.* 2015). Sediment and turbidity can affect fish directly by reducing the gill’s ability to take up oxygen, causing acute toxic reactions, resulting in physiological stress, and reducing foraging efficiency and/or predator avoidance. Resuspension of fine sediment with high organic content can affect fish indirectly by reducing DO levels. For all fish species in which effects to early life stages have been measured, it is clear that eggs and larvae are the most sensitive to suspended sediments and sediment deposition. The deposition of sediment from dredging or other human activities can be harmful to eggs and larvae through burial or encasement of eggs in fine particles occupying interstitial spaces, and these earlier stages are unable to avoid this stressor because of their limited mobility.

Consequences of dredging will vary based on site-specific conditions (Wilber and Clarke 2001). Site-specific conditions (e.g., bathymetry, currents) and material (e.g., sand versus silt) should be considered as they may influence turbidity and re-suspended sediment at a particular site. Assessing exposure of listed species to elevated levels of turbidity or TSS concentration requires an understanding of the sources (e.g., dredge type), factors that influence the duration and intensity of exposure (e.g., sediment type and/or current), as well as the individual species tolerance to the anticipated level of exposure at a given life stage. In our analysis, we consider information from earlier studies of sediment resuspension and turbidity to understand the intensity and extent of turbidity impacts. However, we also consider site-specific information to understand how local conditions influence turbidity and re-suspended sediment.

8.3.1 Consequence Thresholds for Total Suspended Sediment (TSS) and Turbidity

Literature reviews about the consequences of suspended sediment on fish show that impacts varies greatly among species and suggest that concentrations of suspended solids can reach thousands of milligrams per liter (mg/L) before an acute toxic reaction is expected to occur (Burton 1993, Kjelland *et al.* 2015, Wilber and Clarke 2001). Burton (1993) evaluated consequences 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 consequences 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 consequences but also the duration at which a fish is exposed. Most studies report response after exposure ranging from 24 to 48 hours.

There have been no directed studies on the physiological consequences 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 at least as tolerant to suspended sediment as other estuarine fish. Therefore, we expect 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.

High TSS levels can cause a reduction in DO levels. Both Atlantic and shortnose sturgeon may become stressed when DO falls below certain levels. Jenkins et al. (1993) observed that younger shortnose sturgeon experienced high levels of mortality at low DO levels while older individuals tolerated those reduced levels for short periods of time. Tolerances may decline with chronic exposure to low levels. Johnson (2018) recommends that sturgeon should not be exposed to TSS levels of 1,000 mg/L above ambient for longer than 14 days at a time to avoid behavioral and physiological consequences. During times when early life stages could be present in an action area, they should not be exposed to less than 50 mg/L of TSS.

As is the case with physiological consequences, 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 behavioral consequences 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 consequences, is not likely to substantially impact 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 protuberant 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 the night (Dadswell *et al.* 1984). Based on foraging method, tolerance to high turbidity, and foraging during nighttime, it is unlikely that visual detection of prey is of major importance for Atlantic and shortnose sturgeon foraging success. Whereas, elevated TSS levels resulting in physiological consequences 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).

8.3.2 Extent and intensity of water quality changes

8.3.2.1 Dredging

Hydraulic Cutterhead Dredge

Cutterhead dredges use suction to pump sediment through a pipeline into 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 resuspended during lateral swinging of the cutterhead as the dredge progresses forward. Modeling results of cutterhead dredging indicate that TSS concentrations above background levels can be present throughout the bottom six feet (1.8 m) of the water column for a distance of approximately 1,000 ft (305 m) (ACOE 1983). Elevated suspended sediment levels are expected to be present only within a 984.3 to 1,640.4-foot (300-500 m) radius of the cutterhead dredge (ACOE 1983; LaSalle 1990; Hayes et al. 2000, as reported in Wilber and Clarke 2001). TSS concentrations associated with cutterhead dredge sediment plumes typically range from 11.5 to 282.0 mg/L with the highest levels (550.0 mg/L) detected adjacent to the cutterhead dredge and concentrations decreasing with greater distance from the dredge (Nightingale and Simenstad 2001; ACOE 2005, 2010, 2015b).

Mechanical Dredge

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) (ACOE 2001). Furthermore, a study by Burton (1993) measured TSS concentrations at distances of 500, 1,000, 2,000, and 3,300 ft (152, 305, 610, and 1006 m) from dredge sites in the Delaware River and were able to detect concentrations between 15 mg/L and 191 mg/L up to 2,000 ft (610 m) from the dredge site. In support of the New York/New Jersey Harbor Deepening Project, the U.S. Army Corps of Engineers conducted extensive monitoring of mechanical dredge plumes (ACOE 2015a). The dredge sites included Arthur Kill, Kill Van Kull, Newark Bay, and Upper New York Bay. Although briefly addressed in the report, the effect of currents and tides on the dispersal of suspended sediment were not thoroughly examined or documented. Independent of bucket type or size, plumes dissipated to background levels within 600 ft (183 m) of the source in the upper water column and 2,400 ft (732 m) 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 settle rapidly within a 2,400- foot (732 m) radius of the dredge location. A turbidity curtain will be used during mechanical dredging as practicable where water depths and current velocities allow for effective deployment and operation. A turbidity curtain will reduce the extent of the turbidity plume. However, as it is not known if it will be practicable to deploy a turbidity curtain, we assume the worst-case scenario that a turbidity curtain will not be practicable and that turbidity will extent 732 meters from the dredge.

8.3.2.2 Pile driving

Pile installation will disturb bottom sediments and may cause a temporary increase in suspended sediment in the action area. Using available information collected from a project in the Hudson River, we expect pile driving activities to produce TSS concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 300 ft (91 m) of the pile being driven (FHWA 2012). Using a clamshell to extract the timber piles of the existing bulkhead allows sediment attached to the pile to move vertically through the water column until gravitational forces cause it to slough off under its own weight. The small resulting sediment plume is expected to settle out of the water column within a few hours. Studies of the consequences of turbid water on fish suggest that concentrations of suspended sediment can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993). The TSS levels expected for pile driving or removal (5.0 to 10.0 mg/L) are below those shown to have adverse consequence on fish (typically up to 1,000.0 mg/L; see summary of scientific literature in Burton 1993; Wilber and Clarke 2001) and benthic communities (390.0 mg/L (EPA 1986)).

8.3.2.3 Vessel Operation

Hayes *et al.* (2010) estimated that tugs supporting dredging and construction activities can cause significant scour and resuspension of bottom sediments, potentially more than the dredging itself, because they often work in shallow water where the riverbed consists of fine, soft sediment. They modeled resuspension of highly erodible bottom sediment of indefinite depth from various types of vessels at various propeller clearance. They estimated that an 1800 horsepower (HP) tug operating at 25% power and moving forward at one knot could resuspend from 8,300 kilograms per second (kg/s) at 7.7 m propeller clearance to 14,000 kg/s at 1.7 m propeller clearance (Hayes *et al.* 2010). A small push boat with a 180 HP engine could potentially resuspend 1,000 to 5,000 kg/s at 1.4 m propeller clearance depending on power used. Even with a 3.4 m propeller clearance, the small push boat could resuspend up to 70 kg/s if operating at full power. Based on the model results, Hayes *et al.* (2010) concluded that resupension flux by support vessels (tugs) could exceed that of the dredging itself. The tugs supporting dredging and construction of the NJWP will have a draft of approximately 6 m and the project area is generally 6 m MLLW with an average tidal range of 1.7 m. Tugs will not be restricted to the dredge footprint and we expect these to operate within the whole 530 acres of the Project Area.

Similar to most of the sediment transport observations in open-channel flow, the maximum concentration from propeller disturbance of bottom sediment is located near the surface of the riverbed with the suspended-sediment concentration gradually decreasing toward the water surface. Additionally, at any level in the water column, the concentration also decreases with time. Clarke *et al.* (2015) measured TSS concentrations after deep draft vessel passage in the Newark Bay, New Jersey, of 90 mg/l over broad areas following vessels maneuvers. TSS levels remained detectable against ambient levels at least 50 minutes where tidal currents could disperse plumes. Residual plumes (maximum 40 mg/l) in the lower two meters remained detectable at least 65 minutes after deep draft vessel passage. Field measurements of suspended sediment concentration behind a container vessel departing through a restricted fairway at a port in Hamburg, Germany, reached 550 mg/l (Stoschek *et al.* 2014). Concentrations at the focal point of propeller scour when a vessel with little clearance is maneuvering (e.g., at start of movement from a still position) can exceed 1,000 mg/l but the plume will quickly dilute as the vessel start moving and the plume disperses (PIANC 2008, Stoschek *et al.* 2014). Since the vessels described above are larger with more powerful engines and have deeper draft than the tug vessels analyzed here, we expect the measured TSS levels above to be the maximum TSS levels generated by tugs operating in areas with little clearance.

8.3.2.4 Erosion and Stormwater runoff
The release of stormwater during construction of the Port site may temporarily increase suspended sediment concentrations, thus elevating turbidity in the receiving waterbody. Erosion and stormwater runoff associated with adjacent upland activities during construction of the proposed Project could affect water quality for aquatic species, including sturgeon. However, upland construction activities will be conducted in compliance with an approved Stormwater, Erosion, and Sedimentation Control (SESC) plan to minimize water quality impacts. By discharging effluent through a fabric filter, hay bales, or a vegetated buffer strip prior to the effluent entering the receiving waterbody any remaining sediment will be trapped or allowed to settle out of suspension.

8.3.2.5 Compensatory Mitigation
The proposed compensatory mitigation plan includes placement of structures on the benthos in order to enhance an area of soft-bottom, sand, mud, and silt-clay habitat within the Delaware River below Artificial Island or within the Delaware Bay. The placement of these concrete structures could result in temporary, localized increases in suspended sediment at the compensatory mitigation site. Suspended sediment concentrations associated with structure placement are expected to be lower than those associated with dredging and pile driving, and the sediment plumes associated with structure placement would likely be smaller compared to those

activities as well. As a proxy to evaluate potential sediment concentrations and turbidity plumes, we use turbidity associated with plowing with a water jet. Jet plow technology has been shown to minimize impacts to marine habitat caused by excessive dispersion of bottom sediments, but some increased turbidity and resuspension of sediments can be expected (Johnson 2018). Based on the Applied Science Associates, Inc. (ASA) model used by the ESS Group, Inc., the maximum suspended sediment concentration at 20 m (65 ft) from the jet plow is 235.0 mg/L, with concentrations decreasing to 43.0 mg/L within 200 m (656 ft) from the plow. Based on the model used by the ESS Group, Inc., and information provided by Upstate NY Power Corp (the permit applicant), elevated levels of suspended sediment are predicted to return to ambient conditions within 24-48 hours after plowing operations.

8.3.3 Exposure to suspended sediment

Early life stages and YOY sturgeon are not likely to be present at or adjacent to the NJWP project area, and, therefore, will not be exposed to suspended sediment and elevated turbidity caused by project activities. Erosion and stormwater runoff from upland construction of the NJWP could occur any time of the year. However, we expect the implementation of a SESC plan to eliminate listed species exposure to elevated concentrations of suspended sediment. Dredging and pile driving will occur between July 1 and March 15 the following year. During this period, juvenile shortnose sturgeon and Atlantic sturgeon, adult shortnose sturgeon and Atlantic sturgeon, and subadult Atlantic sturgeon occur within the Project Area. Thus, dredging and vessel operations may expose all these life stages to elevated suspended sediment concentrations and turbidity. The USACE has not proposed any time of year restrictions for in-water work for the placement of structures associated with the compensatory mitigation plan. Thus, placement of the mitigation structures may expose older Atlantic sturgeon juveniles that have moved into the lower estuary or the Delaware Bay as they prepare for seaward migration. It may also expose subadult and adult Atlantic sturgeon as they migrate through the bay and river or take up seasonal residency in the lower estuary or the Delaware Bay. Adult shortnose sturgeon infrequently move into the high salinity waters of the lower estuary and bay but placement of the structures could expose any shortnose sturgeon that do occasionally move into that area.

8.3.4 Response to exposure

Juvenile and adult sturgeon frequent turbid water and are capable of avoiding any bottom sediment plumes 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 550 mg/L (cutterhead dredging) and pile driving produces even lower concentration levels. We also expect TSS concentrations from moving vessels to be less than 550 mg. These levels is below those shown to have lethal and sublethal effects on estuarine fish (typically up to 1,000.0 mg/L; see summary of scientific literature in Burton 1993, and Wilber and Clarke 2001). Occasionally, some localized, short-term concentrations above 1,000 mg/l can occur at the propeller scour focal point behind a vessel during vessel maneuvering with very little clearance in an area with highly erodible fines but we expect sturgeon to avoid the turbidity plume and the high velocity and turbulent propeller jet. Thus, we do not expect them to be exposed to the higher concentrations near the scour. Even for suspended sediment concentrations above 1,000 mg/l, the fish will have to be exposed for hours or days before physical injury occurs (section 3.3.1). Based on this, we do not expect sturgeon exposed to the sediment plume to have lethal or sublethal consequences.

TSS is most likely to affect juvenile and adult sturgeon if a plume causes a barrier to normal behaviors. However, the increase in TSS levels expected from the proposed action are below those shown to have adverse consequences on fish. Moreover, sturgeon are likely to avoid the sediment plume at the focal point where the propeller jet hits the bottom and suspended sediment concentrations are highest. Thus, we expect sturgeon to either swim through the plumes or make small evasive movements to avoid them.

Even if sturgeon avoid the turbidity plume, this will not be a barrier to migration. Elevated suspended sediment levels that may cause avoidance at the Port site include the sediment plumes generated by pile driving, hydraulic dredging, and mechanical dredging with radii of 91 m, 500 m and 732 m, respectively. Given the river width at where the NJWP will be located (approximately 4 km), the plumes would affect 2 to 18% of the River’s cross-section. The sediment suspended during dredging will quickly decrease to low concentrations as the distance increases from the dredging area and the sediment falls out of the water column. Any TSS levels that may cause avoidance will be closer to the dredging than the full extent of the sediment plume. The placement of concrete structures for compensatory mitigation may extend up to 200 m from the structure placed on the river bottom in an even wider area of the river. Thus, any avoidance of the plume will not hinder upstream or downstream movements of sturgeon.

Energy expenditure to avoid turbidity plumes could reduce growth of sturgeon that delays ocean migration and eventually expected lifetime fecundity. Sturgeon will use extra energy to avoid the turbidity plumes. However, sturgeon feed on a large range of prey and actively move over the riverbed in search of forage. The small evasive movements necessary to avoid high TSS concentrations would be within their normal range of movements and we do not expect this to substantially increase their normal energy expenditure. Thus, it is unlikely that these movements will result in a measurable consequence on growth or fecundity of sturgeon.

8.3.5 Consequences of Interaction with Suspended Sediment

Construction of the Port and compensatory mitigation structures may expose older juveniles and adults of both shortnose and Atlantic sturgeon to TSS concentration and turbidity above baseline conditions. However, TSS concentrations will be below concentrations that would cause physiological consequences and the increased turbidity is unlikely to affect foraging habitat or the ability for either species to feed. Thus, no injury or mortality will occur. Sturgeon may avoid turbidity plumes but this will not be a barrier to migration or other essential life activities. Sturgeon may make small evasive movements to avoid turbidity plumes but these small adjustments are unlikely to affect growth, survival, or fecundity. Based on these considerations, we do not expect the interaction with suspended sediment to reduce the fitness of sturgeon within the action area.

8.4 Benthic Habitat Modification and Loss of Forage

The proposed project will remove and disturb the riverbed through dredging and scour from the propeller jet of vessels. Further, placement of hard structures on the seafloor will convert the bottom from soft to hard substrate.

Soft substrate support a variety of benthic invertebrates that are important prey for sturgeon. Therefore, removal and disturbance of the bottom sediment or conversion of the riverbed from soft to hard substrate can eliminate or reduce forage for sturgeon. This can again limit forage available to sturgeon and reduce the numbers that an area can support. Widespread habitat loss and deterioration decreases the carrying capacity of the river habitat and/or can impact the fitness of individuals.

In this section, we present background information on the existing habitat and the proposed project's impacts; the established thresholds and criteria to consider when assessing habitat impact; an analysis of exposure; and a summary of available information on sturgeon habitat use and available information on sturgeon responses to loss of habitat and forage. We then consider the consequences of exposure of individual sturgeon to habitat loss and degradation.

8.4.1 Intensity and Extent of Habitat and Forage Impacts

The Project Area consists of soft substrate that supports a variety of benthic invertebrates that are important prey for sturgeon. For instance, grab samples found that polychaete worms were found in the benthic samples throughout the dredge footprint. The benthic invertebrate data from the benthic grab samples were largely consistent with those from previous studies near Artificial Island, where the benthic community was also largely composed of polychaetes, oligochaetes, and isopods. Further, sonar scans of the riverbed show that the bottom topography throughout a majority of the Project Area consists of sand ripples and megaripples.

Dredging

Initial dredging with hydraulic cutterhead and mechanical bucket dredge will occur over a two-year period. Excluding the landward excavation area, the dredge footprint occupies approximately 85 acres of the existing riverbed. The project area will be dredged to an elevation of -35.5 ft NAVD88 with an estimated over-dredge of -0.5 m (-1.5 ft) for a total potential dredge depth of -37 ft NAVD88 (-34 ft MLLW). Thus, dredging will temporarily remove all benthic invertebrates within the dredge footprint and permanently remove structurally complex sand wave habitat. We expect that this disturbance is more likely to disturb or displace non-mobile organisms that occur at the surface of the sediment and is less likely to impact mobile invertebrates (such as crabs). Dredging is likely to entrain and kill at least some of mobile invertebrates. Further, turbidity and suspended sediments from dredging activities may affect benthic resources in those areas. Some of the TSS levels expected for the proposed activities (ranging from 445 mg/L to 550 mg/L) exceed the levels shown to have adverse consequences on benthic communities (390 mg/L (EPA 1986).

Studies done by Wilber and Clarke (2001) demonstrate that benthic communities in temperate regions occupying shallow waters with substrate of sand, silt, or clay reported recovery times between one and 11 months after dredging. Therefore, if a dredge site remains undisturbed after dredging, the benthic invertebrate fauna within the dredged areas could recover to pre-project conditions within one year following completion of the initial dredging. However, we do not know how the change in depth (from 6 to 11.3 m) may affect composition and density of the invertebrate fauna.

Maintenance dredging will occur three times over a 10-year period. Approximately 500,000 CY of sediment will be dredged during maintenance dredging. Thus, we do not expect maintenance dredging to occur over the whole 85 acres and dredging will remove sediment to a considerably shallower depth than the initial dredging. Burrowing polychaete worms, amphipods, and mollusks can migrate vertically through sediment 15 to 32 cm deep (Maurer *et al.* 1982, Robinson *et al.* 2005). Benthic fauna that survives the dredging process can also contribute to quick recovery of the dredge area. However, maintenance dredging could reduce available forage for up to a year after dredging within some of the access channel. Therefore, maintenance dredging will result in reduced forage for sturgeon within the project area 30 percent of the time.

Vessel Traffic

Vessels maneuvering in shallow waters can result in major erosion of the riverbed and suspension of sediment (Breedveld *et al.* 2018a, PIANC 2008, Stoschek *et al.* 2014). 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 that can cause considerable scour to the riverbed (Breedveld *et al.* 2018a, Hong *et al.* 2013, Hong *et al.* 2016, Karaki and van Hoften 1975). 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 in narrow channels and while docking (Karaki and van Hoften 1975, PIANC 2008).

Several theoretical models and empirical methods to calculate the amount of scour and sediment transport caused by propeller shear stress and jet propulsion have been developed (Breedveld *et al.* 2018b, Hong *et al.* 2016, PIANC 2008, Stoschek *et al.* 2014). However, the USACE has not provided any analysis of consequences from operation of the Port and we cannot quantify the amount of bed erosion and sediment resuspension, 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, and the density of vessel traffic. Nevertheless, studies of berthing areas and docks show that vessels maneuvering at docks commonly result in substantial scouring of the riverbed and increased total suspended sediment in the water column (Breedveld *et al.* 2018b, PIANC 2008, Stoschek *et al.* 2014). Because the propeller-induced bed velocity and shear stress is strongest when vessels start from a still position, are repositioning, or are increasing its use of horsepower, resuspension and deposition are expected to be highest during a vessel's maneuvering and docking operations, i.e. situations where vessels start, stop, accelerate, and decelerate (Karaki and van Hoften 1975, PIANC 2008). The installation and delivery vessels will have a minimum clearance of 2.7 to 2.1 meters. We expect the propeller jets from these large vessels to hit the bottom in the access channel, turning basin, and berths. Vessels approaching, docking at, and departing from the Port may use DP thrusters to maneuver and maintain position in the turning basin and berthing areas. The water jet from thrusters have been shown to cause erosion (PIANC 2008). Thus, the DP thrusters, as well as vessel propellers and hulls, have the potential to disturb the river bottom and associated benthic invertebrate community in the access channel, turning basin, and berths.

The vessels docking at the proposed NJWP will have large sized propellers, dock frequently during offshore wind developments, and have a draft clearance of less than 3 m in the access channel and the docking site. Therefore, we expect the operation of the terminal will result in continuous disturbance of sediment and the density and composition of benthic invertebrates. Further, vessel activity and propeller motion when vessels are arriving and leaving the berth are likely to disturb sturgeon or cause vessel strike of sturgeon that are present within or adjacent to the berthing area. Based on these considerations, we conclude that the operation of the terminal will cause a permanent degradation of sturgeon foraging habitat within the project area.

8.4.2 Exposure to changes in habitat and forage

As previously described, older juvenile and adult shortnose sturgeon and Atlantic sturgeon as well as subadult and adult Atlantic sturgeon occur within the lower tidal reach of the Delaware River and the NJWP site. Both Atlantic sturgeon and shortnose sturgeon commonly use depths of 6 m or deeper in the Delaware River. The area between the Philadelphia to the Sea Navigation Channel and the Artificial Island is generally -6 m MLLW up to the western edge where it overlaps with the eastern edge of the Federal Navigation Channel and slopes steeply down the channel wall onto the floor of the 14 m deep channel. Thus, the depth at the Port site is within the depth range where sturgeon are commonly found.

These fish will be exposed to the temporary loss and permanent reductions of benthic prey within the project area. The dredging and bottom disturbance by vessels will result in the loss and reduction of prey within an 85-acre area at Artificial Island. Within the 120 acres that the mitigation site, conversion of soft substrate to hard substrate will cause the permanent loss of one-acre of soft substrate that provides benthic invertebrate forage. The action area within the saline reach of the tidal river (RKM 107.8 to 78) is 2,604 acres. Assuming that dredging and vessel disturbance of the Philadelphia to the Sea Navigation Channel bottom negatively affect benthic invertebrate substrate within the navigation channel, the acreage of habitat with undisturbed bottom sediment is 650 acres of which the 86-acre dredging footprint and placement of concrete structures equals 13.2 percent. The bank-to-bank area of the river from RKM 78 to 107.8 (RM 48 to 67) equals approximately 29,430 acres. Excluding the navigation channel (1,954 acres) leaves 27,476 acres. Thus, the proposed project will result in temporary and permanent reduction of forage within 0.3 percent of undisturbed habitat. Based on this, the proposed project will expose Atlantic sturgeon and shortnose sturgeon to a reduction of forage within 13.2 percent of the action area within RKM 78-107.8 and within 0.3 percent of the river channel between RKM 78 and 107.8.

Approximately 83.4 acres of sandwave habitat will be lost within the dredge footprint (section 3.7). The USACE did not provide the acreage covered by sand ripples and megaripples within the 530-acre Project Area but did note that it occur throughout a majority of the Project Area. Therefore, we assume that this type of habitat occurs throughout most of the 530-acre project site. Because of dredging and vessel disturbance, there is no sand wave habitat within the navigation channel. The mitigation site will not have sand wave habitat as the structures will be purposely placed where such habitat is not present. Thus, the proposed project will expose mature Atlantic sturgeon to an approximately 16 percent total loss of sand wave habitat within the Project Area.

8.4.3 Response to changes in habitat and forage

Juveniles and adults of both species likely forage on the benthic invertebrates that are present within the action area. Atlantic sturgeon juveniles may use the mesohaline reach of the river to acclimate to increasing salinity as they move downstream and before eventually move into the oligohaline Delaware Bay and marine waters. Therefore, the shelf off of Artificial Island may provide important foraging while Atlantic sturgeon remain in the mesohaline reach of the river. The proposed project will result in removal of 85 acres of forage within the dredge footprint for up to two years reduce the density of forage for up to 25 years during operation of the NJWP, and result in a one acre permanent conversion of soft substrate to hard substrate. This will cause a shift in distribution within the action area and limit forage available for sturgeon within the action area over the short- and long-term (up to 13.2 percent). However, the action area still contains of approximately 564 acres of bottom substrate that is undisturbed by dredging, major deep draft vessel traffic, or habitat conversion. Further, the action area constitutes only a small percentage of the river channel between RKM 78 and 107.3. Within this reach and excluding the navigation channel, the proposed project will expose sturgeon to only 0.3 percent reduction in forage. Younger Atlantic sturgeon and shortnose sturgeon move seasonally between the lower estuary at the mouth of the river and the area above Wilmington, Delaware. We assume they use this whole area for foraging. Thus, the temporary loss of 85 acres of foraging habitat, the permanent loss of one acre of foraging habitat, and the long-term reduction in forage within the dredge footprint represents a very small percentage of foraging habitat used by the sturgeon.

Fox and Madsen (2016) suggested that sand waves add a complexity to an otherwise largely uniform river bottom allowing spawning adults a hydrodynamic refuge during periods of reduced foraging and/or fasting that are thought to accompany spawning. The proposed project will expose adult Atlantic sturgeon to a 16 percent (84.3 acres of sandwave habitat divided on 530-acre Project Area) loss of sand wave habitat within the action area. Approximately 467 acres will remain intact. Further, we expect that sandwave bottom habitat to be present in a larger area between the Philadelphia to the Sea Navigation Channel and the Artificial Island shoreline. Therefore, we expect that the percent loss of sandwave habitat within the river channel is less than 16 percent.

The spawning run of Atlantic sturgeon in the Delaware River is estimated to less than 300 individuals. Thus, it will be a minimum of 1.5 acres of sandwave habitat per adult sturgeon. Based on this, we believe that there is ample of sandwave habitat available. While Fox and Madsen (2016) suggested that sandwave habitat provides refuge for Atlantic sturgeon adults during spawning migration, the importance of this kind of habitat for adult fitness is not clear. Nevertheless, we expect that the proposed project will not meaningfully limit sandwave habitat for hydrodynamic refuge during periods of reduced foraging and/or fasting that accompany spawning.

8.4.4 Consequences of Habitat Modification and Loss of Forage

When added to baseline bottom disturbances, the proposed project will affect a relatively large portion of river bottom and reduce the availability of benthic invertebrate prey. This will affect sturgeon distribution and foraging within the action area. However, the action area still provides ample available undisturbed bottom habitat, and the temporary loss of benthic invertebrates within the 85 acres dredge footprint, permanent loss due to mitigation structures, and the long-term reduction of forage within the NJWP access channel is small relative to the amount of bottom habitat present in the Delaware River estuary. Therefore, we do not expect the proposed project to limit forage for juvenile Atlantic sturgeon or shortnose sturgeon population. We similarly expect that the action area and lower estuary will provide ample forage for adult Atlantic sturgeon as they move through the area during the spawning migration. As such, we do not expect this small impact to available foraging habitat caused by the proposed project to limit forage to an extent that would significantly impair essential behavioral patterns. Based on this, we have determined that the consequence to sturgeon from dredging, vessel use of the NJWP access channel and turning basin, and placement of concrete structures is too small to be meaningfully measured, detected, or evaluated. Therefore, consequences are insignificant.

The dredging of the NJWP access channel will result in the loss of approximately 84.3 acres of sand wave habitat that that adult Atlantic sturgeon may use for hydrodynamic refuge during spawning migrations. However, the action area will still provide ample sandwave habitat and, therefore, we do not anticipate that the loss will significantly impair essential behavioral patterns. Based on this, we have determined that the consequences of losing 84.3 acres of sandwave habitat when added to baseline is too small to be meaningfully measured, detected or evaluated. Therefore, consequences are insignificant.

8.5 Vessel Strike

In this biological opinion, we consider if the increase in vessel traffic, when added to the baseline, will increase the risk of interactions between sturgeon and vessels in the action area within the Delaware River.

Construction and operation of the NJWP will include an increase in vessels operating within the Delaware River and the Delaware Bay. Vessels supporting construction and dredging will operate within the Philadelphia to Trenton and the Philadelphia to the Sea Navigation Channels over a two-year period. The proposed project will result in the maneuvering and movement of vessels within the Port’s access channel and the Philadelphia to the Sea Navigation Channel during the expected 25-year lifespan of the NJWP. Last, the creation of complex, structured habitat as part of the compensatory mitigation plan could attract recreational anglers to that site.

An operating 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. Examination of sturgeon carcasses in the Delaware River and the James River shows that the majority of carcasses found have damages consistent with vessel strike (Balazik *et al.* 2012d, Brown and Murphy 2010; also, see discussion in previous sections of this Opinion). Direct observations of vessels strikes killing sturgeon have also been reported (e.g., Park 2017, personal communication).

The timing and location of vessel traffic in the action area 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 (Fisher 2011, Hondorp *et al.* 2017). Similarly, narrow channels or passageways with restricted clearance may increase the probability that sturgeon will be struck and killed by a vessel (Balazik *et al.* 2012d).

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

An evaluation of the consequences of increased vessel traffic associated vessels transiting between the mouth of Delaware Bay and offshore wind development construction areas in the Atlantic Ocean will be completed by the Bureau of Ocean Energy Management ("BOEM") as part of the permitting process for each (once determined) individual offshore wind project. Therefore, the consequences of vessel interactions associated with those projects are not assessed in this biological opinion.

8.5.1 Factors Relevant to Vessel Strike

For sturgeon to interact with vessels and their propellers, they must overlap spatially and temporally. First, a vessel's activity has to occur in the same reach of the river where sturgeon are present. Second, a particular sturgeon life stage has to occupy the same portion (lateral location) of the river channel as the vessel (*e.g.*, the maintained navigation channel versus the non-navigational portion of the channel or waterway). Lastly, the hull, propeller, and the hydrological forces around the vessel have to be at the same depth in the water column as the sturgeon. Factors relevant to determining the risk of 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.). Physical characteristics of the river (*e.g.* narrow channels, channel constrictions, etc.) may also be relevant risk factors.

For a vessel strike to occur, the sturgeon must either not respond to an approaching vessel (i.e. moving away) or is unable to avoid the vessel for any number of reasons. It is well documented that adult and juvenile sturgeon are specifically killed by interactions with vessel propellers of large vessels (Balazik *et al.* 2012d, Brown and Murphy 2010, Demetras *et al.* 2020, Killgore *et al.* 2011). Therefore, it is clear that not all sturgeon respond to an approaching vessel by moving out of its way, and are not able to evade the propeller(s) even if they do attempt to move when approached by a vessel. A few studies have used VEMCO Positioning System (VPS) receiver arrays to study Atlantic sturgeon response to approaching vessels. Preliminary tracking studies in the James River indicate that Atlantic sturgeon seem to be oblivious to the threat of vessel propellers and that they do not make any effort to leave the navigation channel or avoid approaching and passing deep draft vessels (Balazik 2018 personal communication, Balazik *et al.* 2017a). Rather, occasionally the researchers observed sturgeon move into the path of an approaching vessel (Balazik *et al.* 2017a). DiJohnson (2019) studied Atlantic sturgeon responses to approaching vessels in the Delaware River similarly using a VEMCO Positioning System to monitor fine-scale movements of telemetered adults and subadults as large vessels approached. The recently completed study found no evidence that Atlantic sturgeon altered their behavior in the presence of approaching commercial vessel traffic in the Delaware River (DiJohnson 2019). Both Balazik *et al.* (2017a) and DiJohnson (2019) concluded that their findings suggest that Atlantic sturgeon either do not consider vessels a threat or they cannot detect them until it is too late.

The hull itself may hit sturgeon that fail to avoid a vessel and cause injury or mortality. It seems likely that the chance of injury and death by impact increases with the vessel's speed and mass but we do not know at what speed mortality occurs for different types of vessels or for different sizes of sturgeon. Fast vessels have been implicated in shortnose sturgeon vessel strikes but there is no information available to suggest a minimum speed necessary for a sturgeon to avoid an approaching vessel nor has a threshold speed at which a sturgeon is injured or killed by a vessel hull been defined. More often observed is evidence that vessel strike mortalities occur when a propeller hits a sturgeon. The propeller may hit a sturgeon that is directly in the path of a vessel or when the water being sucked through a propeller entrains a sturgeon. Entrainment of an organism occurs when 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. 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. Thus, as the boat propeller draws water through the propeller, it can also consequently entrain an organism in that water. 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 go through the propeller.

Entrainment can occur if a sturgeon is exposed to the water being sucked into the propeller and that individual is not able to escape the current velocity as water is drawn through the propeller. The zone of influence, the part of the water body being entrained through the propeller, is the depth, width, and length in front of the propeller at which water is drawn through a propeller. Models of water entrained during maneuvering of tow vessels in the Mississippi River found the volume of water to be about twice the propeller area times the distance travelled (Wilcox 1991). 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 m in diameter, towboats and tugs commonly have propellers between 2-3 m in diameter, and tankers and bulk carrier vessels with a 40-foot draft may have propellers that are 7-8 m in diameter. Typically, most vessel types have two propellers, but larger vessels may occasionally have three. Thus, we expect large tugboats, cargo vessels, and tankers to have a substantially larger zone of influence than recreational or smaller fishing vessels. Maynord

(2000) showed that the inflow zone of a propeller surrounds the vessel in an area limited to roughly the size of the cross section of the vessel, (i.e. similar to the width of the vessel). As an example, a tow with a draft of 2.7 m pushing three barges side by side (total width of 32 m) in 4.3 to 12 m deep water and a speed (relative to water) of 2 m/s (3.9 knots) had an inflow zone of about 25 m on either side of the center line. Thus, water within a 50 m wide zone could go through the propeller. Besides vessel specifications, the depth relative to draft determines the propeller's lateral zone of influence. In Maynord's calculations, bottom water at depths of 9.8 m or greater were not drawn into the 2.4-m diameter propeller (for a towboat with a 2.7 m draft) while water at depths of 5.6 m or less was drawn into the propeller, though not all flow within this zone would go through it. Therefore, a demersal sturgeon below a large vessel with a clearance of 6 m or less would be exposed to water drawn through the vessel's propeller(s). Further, while sturgeon are benthic feeders, they also use the upper water column during non-foraging movements and migrations and commonly jump out of the water. Therefore, we consider all sturgeon in the path of a large vessel (the width of the path being equal to the width of the vessel) to be located in the water column where the moving vessel will expose them to the water drawn through its propellers.

Whether a fish is able to avoid entrainment depends on its location relative to the velocity of the water moved by the propeller and its swimming ability relative to that velocity. It is unclear what the response of a sturgeon will be when exposed to the hydrology around the hull and propeller of a moving or maneuvering vessel. For a vessel at cruising speed, the suction in front of the propeller is moderate, but it is more pronounced if the propeller diameter is relatively small – as it often is for ships designed for operation in rivers (e.g., tugboats) and other areas with draft limitations, or if the forward speed of the ship is slow (Steen 2021, personal communication). We do not have calculations of the approach velocity of water in front of the propellers of the delivery and installation vessels or the tugboats, and, therefore, we cannot evaluate a sturgeon's ability to escape entrainment through the propeller of these specific vessels. However, Steen theorizes that the propellers of large vessels can entrain even large sturgeon.

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 m 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 signs of propeller impact (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.* 2017a, Brown and Murphy 2010).

Killgore *et al.* (2011) found that the probability of propeller-induced injury (i.e. propeller contact with 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 to move through the propeller without being struck by a blade. Similarly, the longer the fish is, the longer time it needs to move through the propeller, thereby increasing the chance that a blade hits it. The injury probability model developed by Killgore *et al.* (2011) shows a sigmoid (or "S" shaped) relationship between fish length and injury rate at a given RPM. The model estimates 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.

As described in the baseline section, 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. 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 (Balazik *et al.* 2012d, 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) indicates that heavy large-towboat traffic on the Mississippi River (vessels with an average propeller diameter of 2.5 m, a draft of up to 9 ft, and travel at approximately the same speed as tugboats (less than 10 knots)), kill a large number of fish by drawing them into the propellers. The study demonstrates 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 River, this estimate cannot directly be used for this analysis. We also cannot modify the rate for this analysis because the type of vessels traveling on the two rivers differs and we do not know (a) the difference in density of shovelnose sturgeon and shortnose and/or Atlantic sturgeon and (b) 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 similarly sized tugboat moving about 11 knots was observed striking and killing an adult Atlantic sturgeon female in the Federal Navigation Channel of the Delaware River in 2016 (Ian Park, DENRC, personal communication, June 2017).

Other factors also affect the probability of vessel interactions with sturgeon. For example, narrow channels can concentrate both sturgeon and vessels into smaller areas and thus increase the risk of vessel strike. Balazik *et al.* (2012b) notes that there is an inverse relationship between channel width and the number of observed vessel strike mortalities in the James River. Sturgeon are likely to use the navigation channels during spawning migrations as well as seasonal movements between summer and overwintering areas (Fisher 2011, Hondorp *et al.* 2017). Because of these behaviors, a higher number of adult Atlantic sturgeon vessel mortalities occur in the Delaware River during spring months (see Baseline section). Besides adults and subadults being exposed to vessels during these months, it has also been suggested that sturgeon swimming higher in the water column during migration increases their exposure to vessels (Balazik *et al.* 2017a, Brown and Murphy 2010, Fisher 2011).

8.5.2 Consequences of Vessel Traffic at Mitigation Sites

The creation of complex, structured habitat as part of the compensatory mitigation could attract recreational anglers to the mitigation site. We cannot estimate the number of recreational vessels that may visit the structures for fishing. However, we expect recreational vessels to operate on the river and bay irrespective of the structures, and the use of these structures for recreational fishing will not increase the number of vessels that operate on the bay or river over baseline. An increase in the risk of vessel strike could occur if the structures attracted both sturgeon and recreational anglers such that sturgeon exposure to recreational vessels increases. However, it is unlikely that the structures will attract sturgeon as sturgeon prefer soft substrate for foraging. Based on this, we do not expect the implementation of the mitigation plan to increase the risk of vessel strike.

8.5.3 Consequences of Vessel Activity during Construction

During construction, tugboats, crew vessels, and dredge vessels will operate in the channel between the Port site on Artificial Island and the Philadelphia to the Sea Navigation Channel. Further, tugboats and barges will bring material and equipment from an upriver contractor yard near Trenton, NJ, to the barge slip at Hope Creek Nuclear Plant, adjacent to the proposed Port. Therefore, Port construction could result in vessel strikes that injure or kill sturgeon. If the construction of the proposed terminal results in a substantial increase in sturgeon exposure to vessels over baseline conditions, then we can expect an increase in vessel strike mortalities.

The channel between Artificial Island and the Federal Navigation Channel is currently free of maintained vessel infrastructure and the only vessel disturbance is traffic to the Hope Creek and Salem Stations and the presence of occasional recreational vessels. As described in the baseline section, an average count of 16 tow or tug vessels transited 100 m by100 m cells along Artificial Island outside of the navigation channel. When all vessel types were included, the project area had an average of 65 vessels transecting a cell (Section 2.6.3).

The USACE estimates that during the two years of construction and dredging, approximately 340 vessel trips to and from the NJWP site will occur annually. This represents a 5.2-fold increase in vessel traffic within the Project Area over the baseline average of 65 vessel transits. This does not account for vessel movements during construction and dredging. Based on this, the construction of the proposed NJWT will result in a significant increase in vessel traffic between the Artificial Island shoreline and the Federal Navigation Channel.

Water depth within the Project Area varies but is generally 6 m MLLW. The average tidal range in this region is 1.7 m (5.5 ft). Construction vessels are expected to have a maximum draft of 6 m (20 ft). Thus, the construction vessels will have little clearance of the river bottom. Based on this, we expect the zone of influence (as defined in section 4.4.1) to include the water column down to the bottom of the channel. Thus, any sturgeon within the trajectory of a vessel will be exposed to water entrained through the propellers of all vessels associated with construction of the terminal.

Most in-water work will occur during the period from July to March. However, the USACE anticipates up to six one-way trips by delivery vessels per week during construction (including upland construction). Thus, it is reasonable to assume that vessel activity during construction will occur during spring as well as fall when studies have documented the highest concentration of juvenile Atlantic sturgeon and juvenile and adult shortnose sturgeon at or near the Project Area (section 2.2). Further, subadults have been collected during winter months and one adult sturgeon was collected in February at the Salem Generation station, which indicates that adult and subadult Atlantic sturgeon are present from July to March. Thus, vessel activity during in-water construction activities overlap with presence of subadult and potentially adult Atlantic sturgeon. Based on the increase in vessel traffic, limited clearance, the timing of activity, and the presence of sturgeon, we expect the proposed project to increase the risk of juvenile and adult shortnose sturgeon and juvenile, subadult, and adult Atlantic sturgeon exposure to entrainment through the propeller as well as directly to the rotating propellers (i.e. they will be located within the trajectory of the vessel and at the same depth as the propeller) within the Project Area.

The anticipated increase in vessel traffic in the Delaware River between the NJWP site and Trenton, NJ, associated with construction of the proposed Port is approximately 340 one-way vessel trips annually over the two years of construction (640 vessel trips total). These vessels will travel approximately 129 km (80 miles) on the Federal Navigation Channel. This part of the river includes the Atlantic and shortnose sturgeon rearing area at Marcus Hook and an identified spawning area near Chester, PA. Atlantic sturgeon likely also spawn at suitable hard substrate habitat in the river upstream of Chester, PA, to Trenton, NJ. It also includes the shortnose sturgeon overwintering areas at and downstream of Trenton, NJ.

Juvenile sturgeon are expected to remain the majority of their time at or near the river bottom during foraging. The navigation channel is approximately 14 m deep and the zone of influence of a tug may extend to a depth of 9 m[29]. Thus, demersal juveniles in the navigation channel are unlikely to be exposed to entrainment through the propeller. However, because of their shallower drafts, tugboats and barges commonly travel in shallower waters outside the navigation channel. Any sturgeon in these areas may be exposed to vessel strike. Further, adult Atlantic and shortnose sturgeon migrating upstream past the NJWP site to upstream spawning areas are expected to move higher in the water column and well within the depth of drafts of tugboats. Sturgeon surfacing occur both in rearing and overwintering areas. Thus, we expect that sturgeon of both species to be exposed to the construction vessels.

Compared to existing vessel traffic in the Delaware River and Bay, construction-related vessel traffic represents an increase in total vessel traffic of 0.7% annually and an annual increase in self-propelled vessel traffic of 1.0%. (They represent a substantially higher percentage if only vessel trips above the Project Area is considered but it is not possible to calculate number of vessel trips only in this section of the river based on the Waterborne Commerce data.) Given this and the considerations above, within the Delaware River, the proposed construction will increase the risk of a sturgeon being exposed to vessel strikes over a two-year period.

As discussed above, we expect that sturgeon exposed to vessels and their propellers are at risk of being killed. Killgore *et al.* (2011) found that the risk of injury or mortality of fish going through

[29] The draft of the tugs is 6 m and we expect water to a depth of approximately 3 m below the hull.

the propeller of a tugboat increased with the size of the fish. Based on a relationship between fish size and injury risk for entrainment through the propeller developed by Killgore *et al.* (2011), entrainment through a propeller could kill from 50 to over 80 percent of juvenile sturgeon and adult shortnose sturgeon while entrainment of a subadult and adult Atlantic sturgeon may result in close to hundred percent mortality. Therefore, as a consequence of exposure to vessels and their propellers during construction and operation, we expect the majority of sturgeon interacting with vessels will be killed.

Given the substantial increase in vessel traffic over baseline conditions, the more than 120 km that vessels will travel within the Delaware River, the size of the vessels and their propellers, the limited clearance between vessel hulls and the riverbed, the known use of the area by sturgeon, and the likelihood that entrainment through a propeller will kill a sturgeon; we expect that construction activities will significantly increase the risk of vessel strike mortality.

We expect that on average one Atlantic sturgeon will be killed for 898 vessel trips or 0.00111 sturgeon per vessel trip (section 2.7.3.3). Thus, over the two years of construction we expect construction vessels will kill 0.76 or one (1) Atlantic sturgeon rounded up. We expect the sturgeon either to be an Atlantic sturgeon juvenile (because of the relatively higher density) or adult (exposure during spawning migration). Since the Atlantic sturgeon is expected to be killed in the river, this sturgeon to be an adult from the NYB DPS. Any juveniles are expected to be the offspring of spawning in the Delaware River and, therefore, of the NYB DPS. Based on reported mortalities within the Delaware River and Bay, one shortnose sturgeon is killed for every 9,430 vessel trips. However, as discussed in section 2.7.3.3, relatively fewer shortnose sturgeon carcasses than Atlantic sturgeon carcasses may be reported (e.g., the public may be less inclined to report shortnose sturgeon because of their smaller size and less “wow” factor). The calculated risk would also be higher if it was possible to calculate vessel trips within the Delaware River only (i.e. not including the Delaware Bay). We also take into consideration the substantially increased risk of vessel strike within the Project Area and operation of the vessels over shortnose sturgeon overwintering areas with high densities of the fish. Based on these factors, we expect that construction vessel traffic associated with the proposed project will result in one shortnose sturgeon vessel mortality.

8.5.4 Consequences of Vessel Activity during Port Operation

As explained in the Project Description above, delivery and installation vessels will travel from the Pilot Area to the proposed terminal using the Philadelphia to the Sea Navigation Channel during the 25-year lifetime of the NJWP. These vessels would not occur but for the proposed NJWP. Despite their relatively small number, such vessels will add to the existing vessel activity in the Delaware River and Delaware Bay. As described previously, interaction between vessels and sturgeon have caused vessel strike mortalities in the Delaware River and Bay. Thus, an increase in vessel traffic caused by the proposed project may result in an increase in vessel strikes to Atlantic and shortnose sturgeon.

8.5.4.1 Vessel Interactions

During operations, two types of vessels will call at the Port: installation vessels and delivery vessels. Installation vessels for offshore wind projects under development in U.S. waters will range in size from approximately 145 m (475 ft) to 152 m (500 ft) in length with a draft of approximately 8.5 m (28 ft). Offshore delivery vessels will be approximately 180 m (590 ft) in length with a draft of approximately 9.1 m (30 ft).

During a three-to-four-month preparation period, about 10 to 12 delivery vessels will call at the terminal per month to deliver offshore wind farm components that will be stockpiled and staged at the Port. During wind farm construction, up to four installation vessels and up to 10 delivery vessels will call at the terminal per month over a six-to-eight- month period. Thus, the USACE and Applicant expect up to 160 vessel calls annually. Both delivery vessels and installation vessels will use the Philadelphia to the Sea Federal Navigation Channel to travel between the Pilot Area and the mouth of the Delaware Bay.

Although installation vessels are capable of berthing themselves, these vessels will also likely be under tug control. Two to three tugs will be required to maneuver an installation vessel. Tugs maneuvering installation and delivery vessels will be up to approximately 32 m (105 ft) in length with a draft of approximately 5.5 m (18 ft). At this time, the homeports of the tugs are not known but we assume they will travel to the NJWP from upstream locations.

Vessels calling at the proposed NJWP will travel through several areas where sturgeon occur in high densities. Delivery and installation vessels will travel through the Delaware Bay mouth during all times of the year. During summer and early fall months, subadult and adult Atlantic sturgeon aggregate and reside in areas at the mouth of the bay (section 2.2). These areas are relatively deep and Atlantic sturgeon at the seabed are unlikely to be exposed to the hydrology around the hull and propellers of the delivery and installation vessels. However, Atlantic sturgeon commonly surface and surfacing will expose the fish to the vessels. Surfacing represents a small fraction of an individual’s total behavior but aggregations of sturgeon increase the chance that a vessel may interact with an individual. The bay mouth is not only an area of residency but also of high occurrence; therefore, the chance of a vessel interacting with a surfacing Atlantic sturgeon is relatively high (Breece *et al.* 2018).

During early spring, mature adults migrate through the narrow bay mouth during the spawning migration while both subadults and adults move through the mouth during seasonal migrations to and from areas of residency within the Delaware Bay. We expect that Atlantic sturgeon will move in a relatively straight line during migration across the Delaware Bay. Such a path across the bay would largely correspond with the Philadelphia to the Sea Federal Navigation Channel. Hondorp *et al.* (2017) found that lake sturgeon selected the higher-flow and deeper navigation channels over alternative migration pathways in Detroit River. Use of the navigation channel likely occurs because channelization modifies current direction, current velocity, and discharge that sturgeon use as hydrologic cues during riverine migration. Thus, as Atlantic sturgeon enter the Delaware River during the spawning migration, they may use the Philadelphia to the Sea Navigation Channel for up and downstream migration. Atlantic sturgeon swim closer to the surface during migration and other directed movements (Balazik *et al.* 2012d, Fisher 2011, Reine *et al.* 2014). Consequently, sturgeon are substantially more exposed to medium draft vessels (e.g. tugs) during periods when active movements occur such as spawning migrations or seasonal movements between habitats. Fish attracted to channelized pathways that coincide with shipping routes may be injured or killed as a result of exposure to the propellers of tugs as well as deep draft vessels. This is exemplified by a tug observed striking and decapitating a gravid female Atlantic sturgeon in the navigation channel of the Delaware River in 2016 (Park 2017, personal communication).

There are no scientific quantitative surveys of vessel mortalities nor exists an annual index survey that provides a time series of the relative number of vessel strikes. 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 resulting from the proposed NJWP will increase the risk of vessel strike to shortnose and Atlantic sturgeon. Additionally, this increased risk will 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. During the period from 2010 to 2019, the annual median vessel trips by self-propelled vessels of all drafts was 33,780 (section 2.6.3.1). We use only the activity of self-propelled vessels to calculate risk of vessel strike as tugs transport non-self-propelled vessels (e.g., barges). Given the high baseline vessel traffic within the Federal Navigation Channel, an annual increase of 1,280 trips would correspond to an approximate 3.8% increase in vessel traffic over baseline conditions.

This section considers the effects of vessel traffic associated with NJWT operations on sturgeon over the approximate 25-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 Section 2.7.3 to calculate an estimate of sturgeon killed.

Atlantic Sturgeon

Juvenile and subadult Atlantic sturgeon may be found in the action area throughout the year, and adults are known to occur there seasonally. Therefore, these life stages of Atlantic sturgeon could interact with the increased vessel traffic associated with the proposed Port. Vessel traffic, consisting of commercial cargo ships, tankers, tug boats, fishing boats, and recreational motorboats, has recently been identified as a significant source of sturgeon mortality in the Delaware, James, and Hudson Rivers (Balazik *et al.* 2012d, Brown and Murphy 2010). Many of the documented mortalities involve large Atlantic sturgeon with severe injuries (e.g., lacerations and amputations). Given the size of the fish and the nature of the injuries, these mortalities are likely caused by deep-draft (≥ 6 m [20 ft]) commercial vessels with large propellers that draw large volumes of water, entraining sturgeon. Though deep-draft vessels may be most likely to cause serious injury or mortality to sturgeon, interactions with vessels are not limited to those with deep drafts (NMFS 2018c).

In the baseline section, we calculated that each vessel trip killed 0.00111 Atlantic sturgeon or that one Atlantic sturgeon is killed for approximately every 898 vessel trips. As we discussed in section 1.5.3, this is a reasonable approximation as the Waterborne Commerce data used included self-propelled vessels of all drafts. We also consider smaller vessels to be less of a threat to sturgeon and account for an extremely 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 operate 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 used 2015 to 2018 data from the Waterborne Commerce Statistics Center to calculate the median number of non-self-propelled vessel trips in the Philadelphia to the Sea Navigation Channel. However, we used vessel trip data for the Trenton to the Sea to include the whole action area and included data to 2019 to correspond with updated vessel strike data. The median annual number of vessel trips for the period from 2010 to 2019 of 33,799 vessel trips per year, as described in the baseline (section 6.7.3), is lower than the annual median of 40,800 for the years 2015 to 2018 calculated by the USACE. USACE used the annual median of 16 Atlantic sturgeon vessel strike mortalities for the period of 2012 to 2016 to calculate the risk of vessel strike. However, DNREC provided us with additional data from 2017 through 2019. Thus, we have used data for the period of 2012 to 2019 to represent vessel-induced mortalities (median=12) within the action area. While cause of death cannot be determined with reasonable certainty for many carcasses, it is likely that most of them as we described in section 1.5.3 and as noted by Brown and Murphy (2010) were the result of vessel strikes. Thus, this analysis as well as the one conducted by the USACE includes sturgeon with unknown causes of death to support a conservative estimate of vessel mortalities.

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 approximately one third of vessel mortalities are reported in the James River. To err 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 (i.e. adjusted to 48 vessel strikes per year). Based on the above, we calculated an estimate of 36 vessel mortalities in the Delaware River occurring annually.

The USACE estimates that the operation of the proposed terminal will add 1,280 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 25-year life span of the project. Thus, approximately 1.4 sturgeon will be killed by the additional vessels per year (0.00111 *1,280) for a total of approximately 35 sturgeon (1.5 sturgeon * 25 years) vessel mortalities over the 25-year life span of the NJWT. Sturgeon entrained in the propeller of vessels could also be injured but survive. This would most likely occur if interacting with a smaller propeller than those expected on the installation and delivery vessels. Both the vessels calling at the proposed Port as well as the tugboats that will support the turning of the vessels have large propellers that rotate with considerable force. Therefore, we find it unlikely that a sturgeon struck by propellers of this size will survive and consider all sturgeon interactions with the vessels analyzed in this biological opinion to be fatal.

Size was reported for about 70 percent of the carcasses reported since 2005. Of the 101 Atlantic sturgeon in the DNERC data that were assumed to be struck and killed by vessels from 2005 through 2019, 18 (17.8%) were characterized as juveniles and 63 (62.4%) were characterized as adults (life stage was not determined for 18 (17.8%) of the fish and two (2.0%) were characterized as subadults). 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. If we assume, to be conservative, that all mortalities with no life stage information were adult fish, then 80.2 percent of the vessel strikes reported to DNREC were adults. We therefore conservatively consider 28 of the estimated 35 vessel mortalities to be adults.

DPS

All juvenile mortalities will belong to the New York Bight DPS. We have considered the best available information to determine the likely DPS origin of subadult and adult individuals. Using the mixed stock analysis explained previously in section 5.2.2, 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 16.24 of the vessel caused mortalities will belong to the NYB, 5.04 to CB, 4.76 to SA, 1.82 to GOM, and 0.14 to Carolina. Given that we cannot have a fraction of a sturgeon killed, we round the number of sturgeon from each DPS as follows: 16 from NYB, 5 from CB, and 5 from SA, and 2 from 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 one 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 DNREC data report the sex for only five adult mortalities (all mortality 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 28 adult vessel strike mortalities estimated for the NYB DPS over 25 years, we anticipate approximately 50 percent males and 50 percent females.

Shortnose sturgeon

The DNREC data (2005 through 2019) includes 13 shortnose sturgeon mortalities. Of these, eight were the result of vessel interactions. For the period 2012 through 2019, six shortnose sturgeon carcasses were reported. The cause of death was considered vessel strike for four of the six while the cause of death was not determined for two. Again assuming that vessel strike caused all mortalities and that only 1/3 of all vessel mortalities are reported, we calculate that 24 vessel mortalities occurred during the eight years. This equals an average of three shortnose sturgeon vessel mortalities per year. Thus, one shortnose sturgeon is killed per 9,430 vessel trips or 0.00011 per trip. Using the same calculation as above, we expect the operation of the NJWP to cause 0.141 vessel strikes per year. Over the 25-year time life of the project, 3.52 or four (4) shortnose sturgeon will be killed by vessel activity related to the operation of the proposed terminal. Shortnose sturgeon present in the action area will be either older juveniles or adults. Further, larger fish have an exponentially higher probability of being killed if entrained through a propeller than smaller fish (Miranda and Killgore 2013, USACE 2017a). Therefore, the shortnose sturgeon will be either older juveniles, adults, or a mix of older juveniles and adults.

8.5.5 Summary of Effects of Vessel Traffic

We expect the additional vessel traffic in the action area due to the construction and the operation of the NJWP will increase the risk of vessel strike in the action area. Based on this, we have concluded that the increase in traffic in the action area is likely to result in an increase in the number of sturgeon killed by vessels. We assume that vessels calling at the Port will stay constant and that the risk will not increase during the next 25 years of terminal operation. Based on information in the biological assessment, the construction of the NJWP will add 640 vessel trips during 2022 and 2023 and the operation of NJWP will add 1,280 vessel trips during the years from 2024 to 2049 to the number of baseline vessel trips. Based on this, we anticipate 36 Atlantic sturgeon vessel strike mortalities over a 27–year period. Of these, eight may be NYB DPS juvenile Atlantic sturgeon. Further, we anticipate that no more than 29 adult sturgeon will be killed during the 27 years. Seventeen (17) of these are likely to belong to the NYB DPS, five (5) to CB DPS, five (5) to SA DPS, and two (2) to GOM DPS. We also determined that it is likely that five (5) adult and/or older juvenile shortnose sturgeon will be killed by vessel strikes over 27 years.

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 could alter the level of risk of vessel mortalities per trip if recreational vessels are a larger threat than assumed.
- The assumption that all self-propelled vessels irrespective of vessel type, vessel size, vessel draft, number of propellers, type and size of propeller, etc. 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 DNREC database that had no identified cause of death as vessel mortalities would overestimate the risk of vessel strike if many of these were actually not killed by interaction with vessels.
- The assumption that the DNNREC database includes only one third of actual sturgeon mortalities in the Delaware River and Bay would result in overestimate of vessel strikes if a higher proportion is reported and an underestimate if even less are reported.
- 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.

8.6 Ballast

Vessels calling at the proposed NJWP are likely to exchange ballast during on- and offloading of cargo. As Atlantic sturgeon and shortnose sturgeon may occur in the action area, these species could potentially be affected by entrainment in the water intake during exchange of ballast water operation of the proposed Port. Atlantic sturgeon and shortnose sturgeon life stages in the action area (i.e., juveniles and older) are too large to potentially be entrained and have sufficient swimming capabilities to avoid impingement during ballast water withdrawal (NMFS 2017a). Invasive species released in the action area could potentially affect sturgeon directly (e.g., a novel parasite) or affect their prey. However, based on anticipated vessel travel within the Delaware River during construction and between the proposed Port and offshore wind farms on the Atlantic Outer Continental Shelf during operation, project vessels are unlikely to be carrying invasive species in their ballast tanks from the marine environment that would survive the low-salinity environment at the proposed Port site and vice versa. Additionally, all Project vessels will be required to comply with the United States Environmental Protection Agency's Vessel General Permit program and with United States Coast Guard ballast water exchange regulations specified at 33 CFR 151.1510 to avoid introduction of invasive species through ballast discharge in the action area. Therefore, the consequences of ballast water exchange on Atlantic sturgeon are extremely unlikely to occur.

9 Consequences of the Action on Atlantic sturgeon Critical Habitat

As we 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 RKM 107.8 (RM 67) 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. The action area overlaps with the full length of critical habitat from RKM 78-213.5. However, the action area is limited to the Project Area, Federal Navigation Channel, and the mitigation site and does not encompass the full width of the river within the Delaware River Critical Habitat Unit (see section 4.0).

In this analysis, we consider the direct and indirect consequences 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 experience consequences of the action, we then determine whether those consequences to the feature are adverse, 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 consequences to the ability of Atlantic sturgeon to access the feature, temporarily or permanently, and consideration of the consequence of the action on the action area's ability to develop the feature over time.

9.1 Physical and Biological Feature 1

Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages

As explained in Section 6.2.3, PBF 1 does occur within the action area from RKM 107.8 to 214. Thus, the only project related activities within PBF 1 is transport of construction material on barges pushed by tugboats. The propeller jet of vessels, including tug and tow vessels, can scour the riverbed. PBF 1 consists of hard substrate such as gravel and bedrock. For the propeller jet to scour the coarse substrate that constitute PBF 1, the tugboats need to have very little clearance to the bottom. However, we anticipate that the vessels will remain most of the time within the federal navigation channel, which will provide 6 to 7.6 meters of clearance between the hull and the bottom. Even when traveling outside of the navigation channel, we expect that they will remain in areas with a depth that provides enough clearance to the riverbed to provide for safe navigation. Tugs and tow vessels with a clearance of 6 m or more should have little impact on the riverbed (PIANC 2008). Further, we expect that tugboats will travel in the navigation channel at a speed of 10 knots or more, and moving vessels at constant speed cause less shear stress on the riverbed than during maneuvering (PIANC 2008, Stoschek *et al.* 2014). Therefore, we do not anticipate that the propeller jet of the tugs will scour the river bottom. Given these considerations, it is extremely unlikely that the proposed project will affect PBF 1.

9.2 Physical and Biological Feature 2

Transitional salinity zone with soft substrate for juvenile foraging and physiological development

In considering consequences to PBF 2, we consider whether the proposed action will have any consequence to areas of soft substrate within transitional salinity zones between the river mouth and spawning sites for juvenile foraging and physiological development; therefore, we consider consequences 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 consequences on the access to this feature, temporarily or permanently. We also consider the consequences 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 salinity increases with age. They also need enough forage to support their energy demands and growth during their transition. PBF 2 occurs from approximately RKM 78 (where the final rule describes the mouth of the river entering Delaware Bay) to approximately RKM 107.8, or the downstream median range of the salt front. As described above, salinity levels in the river are dynamic, and the salt front is defined by a lower concentration (0.25 ppt) than the salinity level of PBF 2 (0.5 ppt), but 107.8 is a reasonable approximation given the lack of real time data and the very small difference we would expect between the area where salinity is 0.5 ppt and 0.25 ppt. As explained in Section 6.2.3, we estimate the area of bank-to-bank critical habitat from RKM 78-107.78 is 29,430 acres, and we estimate that there are approximately 23,016 acres of unconsolidated soft substrates potentially meeting the criteria for PBF 2 between RKM 78-107.8. The action area within this reach is 2,604 acres (project site, navigation channel and mitigation site and assuming the entire navigation channel is soft substrate).

As describe above, initial dredging will result in the removal of up to 1,790,000 CY of fine-grained material to a depth of 37 ft within approximately 85 acres. This will result in total removal of benthic invertebrates immediately after completion of the dredging. The area of PBF 2 negatively affected by dredging may be slightly larger than 85 acres, as areas outside of the dredge footprint impacted by sedimentation from the nearfield turbidity plume of cutterhead and mechanical dredges may experience a loss of benthic life from burial/suffocation. Further, the tugs supporting the dredging and construction activities can cause significant scour and resuspension of the bottom sediment, potentially more than the dredging itself, because they will work in shallow water where the riverbed consists of fine, soft sediment (Hayes *et al.* 2010, Hayes *et al.* 2000). Thus, disturbance of soft bottom sediment will occur within the whole 530-acre project area but only an unknown portion of the area will be disturbed by vessels. We do not expect dredging and vessel traffic to influence the movement or seasonal location of the salt front. In addition, to impacts from construction, the mitigation portion of the project will convert approximately one-acre of soft bottom substrate to hard substrate (i.e. concrete structures) within a 120-acre area.

Following dredging, the ability of access channel, turning basin, and berth to support juvenile foraging and physiological development will be lost until the areas recover and are repopulated by neighboring colonies of benthic invertebrates. Based on (Wilber and Clarke 2001), the benthic community may recover within a year. Therefore, if a dredge site remains undisturbed after dredging, the benthic invertebrate fauna within the dredged areas could recover to pre-project conditions within one year following completion of the initial dredging. However, as described in section 3.7.1, maintenance dredging will result in reduced forage for sturgeon within the project area approximately 30 percent of the time.

As discussed in section 3.4, scour from propeller jets can scour several centimeters deep into the substrate. However, we expect any consequences from a vessel propeller will be of short duration as the area affected will be relatively small and mobile invertebrates from nearby areas will quickly recolonize the scour scar. Further, burrowing Polychaeta worms, amphipods, and mollusks can migrate vertically through sediment 15 to 32 cm deep (Maurer *et al.* 1982, Robinson *et al.* 2005). Thus, propeller scour is not likely to dislodge most burrowing invertebrates. Therefore, the short term and limited vessel activity during construction is unlikely to significantly degrade soft substrate (*e.g.,* sand, mud) that supports juvenile foraging and physiological development, i.e. PBF 2. However, vessel traffic during operation of the NJWP will be concentrated in the access channel and turning basin. Benthic disturbance associated with this vessel traffic could affect prey availability for foraging Atlantic sturgeon within the dredged area. The benthic community in the Project Area includes polychaete worms, isopods, and amphipods, which are common prey items for Atlantic sturgeon. The repeated disturbance that will occur due to vessel traffic during operation of the proposed NJWP in combination with regular maintenance dredging may permanently disturb the soft substrate and benthic community, reducing the quality of PBF 2 within the approximately 85 acres of the access channel, turning basin, and berths. In addition, the placement of structures to create complex sand wave habitat will result in the loss of one-acre of soft substrate assuming the mitigation site is located upstream of the river mouth. This one-acre loss of PBF 2 will be permanent.

The Philadelphia to the Sea Navigation Channel constitutes approximately 1,954 acres of the 29,430-acre shore-to-shore channel area (~7%) between RKM 78 and 107.8. The USACE expects that up to 1,000,000 CY will be dredged every three years from Reach D and 400,000 CY will be dredged annually from Reach C upstream of the NJWP port site. The whole channel will not be dredged at one time, only shoals, but maintenance dredging will reduce availability of benthic invertebrates in the areas where dredging occurs until the benthic fauna reestablish. However, NMFS (2019) notes that given the dynamic nature of the substrates that form these shoals, they may not support as abundant benthic resource as areas outside these shoals in the first place. With thousands of deep draft vessels traveling up and down the navigation channel, the channel bottom is also impacted from prop wash.

When the navigation channel (~1,954 acres) is subtracted from the overall action area that is located within PBF 2, the remaining piece overlapping with critical habitat is 650 acres of potentially high quality habitat. All of this area consists of soft substrate. The benthic community in this area includes polychaete worms, isopods, and amphipods, which are common prey items for Atlantic sturgeon. Based on the best available information on the distribution of juveniles in the Delaware River, juveniles will mostly use the 650 acres in the spring to fall months. Late-stage juveniles may remain in fall while the younger juveniles may move upstream to winter aggregation areas, such as those documented near Marcus Hook (ERC 2016, 2017). Thus, we expect the 650 acres (the Project Area and the mitigation site) to provide PBF 2 that is suitable and valuable for conservation of the species.

The access channel, turning basin, and berth together with the mitigation structures will permanently degrade or remove approximately 13 percent of PBF 2 within the 650-acre area over the next 27 years (two years of construction and 25 years of operation). It is difficult to determine the consequences that this percentage of impact on PBF 2 will have for the value of PBF 2 to support the conservation of the species. We have to consider the function of soft substrate and how it supports juvenile foraging and physiological development in relation to the salinity of the reach where these activities occur. The Project Area and potential mitigation site are located within the mesohaline zone of the river. The mesohaline zone represents a gradual shift in salinity from the upstream less saline oligohaline zone into the downstream highly saline polyhaline waters of the Delaware Bay. Therefore, the action area, particularly the Project Area and mitigation site, provides an area where older Atlantic sturgeon juveniles acclimate to increasing salinity before moving into the polyhaline Delaware Bay and eventually marine waters. This long-term reduction in the amount and quality of soft bottom substrate means that, within the action area, there will be less aquatic habitat available for juvenile foraging and physiological development as older juveniles transition to migrant subadults. We expect this to result in a measurable impact on the conservation function of PBF 2 within the action area for Atlantic sturgeon due to the decrease in the availability and reduction in the quality of soft substrate within the action area between the river mouth and spawning sites for juvenile foraging and physiological development. Therefore, this reduction in the availability of PBF 2 is an adverse effect to the Delaware River Unit of critical habitat designated for the NYB DPS of Atlantic sturgeon.

9.3 Physical and Biological Feature 3

Water absent physical barriers to passage between the river mouth and spawning sites

In considering consequences to PBF 3, we consider whether the proposed action will have any consequence 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, a ;s water is too shallow 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 consequences 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 consequences to access of this feature, temporarily or permanently and consider the consequences 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 NJWP and vessel transit routes. Here we consider whether those activities may affect PBF 3 and if so, whether those consequences are adverse, insignificant, discountable, or entirely beneficial.

The proposed NJWP involves construction of a pile-supported wharf and associated structures. Dredging will create approximately 329 m (1,080 ft) of the new shoreline behind an existing timber bulkhead for the quay; this shoreline will be stabilized with a new bulkhead. The quay structure will be constructed from the bulkhead and extend 57 ft into the newly inundated area of the river from the new shoreline. Thus, the structure will not extend into the river from the existing shoreline, and the proposed action will 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 are temporary and will 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. Further, the Delaware River at the proposed Port site is approximately 4 km wide and turbidity plumes from dredging of the access channel will reach a maximum of 2 km from the Artificial Island shoreline (when dredging at the western end of the 1,500-meter long access channel). Dredging will increase water depths in the access channel and turning basin, but otherwise will not affect water depth within the Delaware River. Based on this information, consequences of the proposed action to PBF 3 are too small to be meaningfully measured, detected, or evaluated; and therefore, are insignificant.

9.4 Physical and Biological Feature 4

Water with the temperature, salinity, and oxygen values that, combined, provide for dissolved oxygen values that support successful reproduction and recruitment and are within the temperature range that supports the habitat function

In considering consequences to PBF 4, we consider whether the proposed action will have any consequence 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 consequences 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 DO saturation for a particular area. We also consider whether the action will have consequences on the access to this feature, temporarily or permanently and consider the consequences 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 sections 4.1.2. and 6.1.2 Based on this information, PBF 4 exists in the action area downstream from RKM 213.5 downstream to where Delaware River empties into the Delaware Bay at RKM 78. Flow, temperature, and DO are likely to be highly spatially and temporally variable throughout the action area. Resuspension of sediment during pile driving may temporarily decrease DO within 91 m from the shoreline but will have no consequences on water temperature or salinity. Dredging will result in increased total suspended sediment within the action area during mechanical and hydraulic dredging, which may also decrease DO. However, the plume will cover very little of the channel and any changes in DO will be short lived because of the large volume of water that is moved during tidal flow. Dredging will not affect salinity or water temperature. The proposed action will increase vessel traffic over baseline conditions but vessels will not alter the salinity, DO, or temperature of water in the Delaware River. Bottom water temperatures in the dredging area and construction area may decrease slightly because of increased depth, 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 will 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 consequences of the project on the value of PBF 4 in the action will be too small to be meaningfully measured, evaluated, or detected. Therefore, any consequences to the value of PBF 4 to the conservation of the species are insignificant.

9.5 Summary of the Consequences of the Proposed Action on Atlantic sturgeon Critical Habitat

We have determined that the proposed construction and operation of the NJWP will have permanent adverse effects to PBF 2. In the Integration and Synthesis section (11.0), below, we analyze whether the adverse effects to PBF 2 will appreciably diminish the value of the Delaware River critical habitat unit as a whole for the conservation of the New York Bight DPS of Atlantic sturgeon. We then consider whether or not the action will destroy or adversely modify the critical habitat designated for the New York Bight DPS.

Consequences to PBFs 1 are extremely unlikely to occur and consequences to 3 and 4 will be so small that they are not able to be meaningfully measured, detected or evaluated and are therefore, insignificant.

10 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." 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[30].

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 (NPDES). 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.

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 biological opinion assumes that future effects would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the status of the species/environmental baseline section.

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

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[30] 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."

11 INTEGRATION AND SYNTHESIS

In the Consequences Analysis outlined above, we considered potential consequences from the construction (including dredging and pile driving) and operation of the NJWP. These consequences include interactions with gear types such as dredges and noise consequences on these species from pile driving. In addition to these consequences, we considered the potential for interactions between ESA-listed species and vessels during construction and operation of the NJWP and impacts to their habitats and prey. We also considered the consequences of impacts to PBFs of critical habitat designated for Atlantic sturgeon.

We concluded that the proposed project may affect but is not likely to adversely affect listed sea turtles and whales (section 5.1). Thus, no take is anticipated or exempted for these species.

We have estimated that the proposed project will result in dredging entrapment of up to two shortnose sturgeon, two Atlantic sturgeon, or one of each. We also concluded that vessel traffic during construction will result in the mortality of one shortnose sturgeon and one Atlantic sturgeon while interactions with vessels calling at the NJWP port construction during operation of the Port will result in the mortality of four shortnose sturgeon and 35 Atlantic sturgeon. As explained in the *Consequences of the Actions* section, all other consequences to shortnose sturgeon and Atlantic sturgeon from the proposed project, including consequences to their prey and habitat will be insignificant and/or discountable.

In the discussion below, we consider whether the consequences 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.

Further, we concluded that the proposed project will adversely affect critical habitat designated for Atlantic sturgeon. Thus, in the discussion below, we consider the impacts of the proposed action on the Delaware River Critical Habitat Unit and whether the proposed action is likely to result in the destruction or adverse modification of critical habitat designated for the New York Bight DPS.

In the U.S. FWS/NMFS Section 7 Handbook (U.S. FWS and NMFS 1998), 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.” We summarize below 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 consider 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 ESA.

11.1 Shortnose Sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 km. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers. As indicated in Kynard *et al.* (2016), adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for 5 of 11 surveyed northern populations and all natural southern populations. The only river systems likely supporting populations close to expected abundance are the St John, Hudson and possibly the Delaware and the Kennebec (Kynard *et al.* 2016), making the continued success of shortnose sturgeon in these rivers critical to the species as a whole.

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

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

As described in the Status of the Species, Environmental Baseline, and Cumulative Effects sections above, shortnose sturgeon in the Delaware River are affected by impingement at water intakes, habitat alteration, dredging, bycatch in commercial and recreational fisheries, water quality, in-water construction activities, and vessel traffic (e.g., data from Delaware’s Department of Natural Resources and Environmental Control (DNREC), indicate that from 2005 through 2017, 8 sturgeon mortalities were attributable to vessel strikes (an additional 3 had an unknown cause of death)). It is difficult to quantify the total number of shortnose sturgeon that may be killed in the Delaware River each year due to anthropogenic sources. Through reporting requirements implemented under Section 7 and Section 10 of the ESA, for specific actions we obtain some information on the number of incidental and directed takes of shortnose sturgeon each year. Typically, scientific research results in the capture and collection of less than 100 shortnose sturgeon in the Delaware River each year, with little if any mortality. With the exception of the five shortnose sturgeon observed during cutterhead dredging activities in the 1990s; the three shortnose sturgeon killed by hopper dredge during 2017- 2019; the shortnose sturgeon injured during the pilot relocation study; and the six shortnose sturgeon killed during blasting (for the Philadelphia to the Sea FNP deepening project) we have no reports of interactions or mortalities of shortnose sturgeon in the Delaware River resulting from dredging or other in-water construction activities. We also have no quantifiable information on the consequences 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, facilities with intakes in the upper river have impinged and entrained larvae but documented instances are rare and have involved only small numbers of larvae. The shad fishery, primarily hook and line recreational fishing, has historically caught shortnose sturgeon as bycatch, particularly because it commonly occurred on the spawning grounds. However, little to no mortality was thought to occur and due to decreases in shad fishing, impacts are thought to be less now than they were in the past. Despite these ongoing threats, the Delaware River population of shortnose sturgeon is stable at high numbers. Over the life of the action, shortnose sturgeon in the Delaware River will continue to experience anthropogenic and natural sources of mortality. However, we are not aware of any future actions that are reasonably certain to occur that are likely to change this trend or reduce the stability of the Delaware River population. If the salt line shifts further upstream as is predicted in climate change modeling, the range of juvenile shortnose sturgeon is likely to be reduced compared to the current range of this life stage. However, because there is no barrier to upstream movement it is not clear if this will impact the stability of the Delaware River population of shortnose sturgeon; we do not anticipate changes in distribution or abundance of shortnose sturgeon in the river due to climate change in the time period considered in this Opinion. As such, we expect that numbers of shortnose sturgeon in the action area will continue to be stable at high levels over the life of the proposed action.

We have estimated that the proposed activities will result in the following levels of take:

- We anticipate that initial and maintenance dredging will kill up to two shortnose sturgeon between now and 2049. Both may be juveniles, adults, or one of each.
- We anticipate that vessel traffic during two years of construction will kill one shortnose sturgeon and that vessel traffic to and from the NJWP during 25 years of port operations

will result in four shortnose sturgeon vessel strike mortalities. These will be juveniles, adults, or a mix of both.

The number of shortnose sturgeon that are likely to die as a result of as a result of the project, represents an extremely small percentage of the shortnose sturgeon population in the Delaware River, which is believed to be stable at high numbers, and an even smaller percentage of the total population of shortnose sturgeon range wide, which is also stable. The best available population estimates indicate that there are approximately 12,047 shortnose sturgeon in the Delaware River (ERC 2006b). While the mortalities associated with completed actions together with the estimated mortalities associated with proposed activities from now through 2070 will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population or its stable trend as this loss represents a very small percentage of the population (adult and juvenile mortalities would be approximately 0.06% of the total population). The effect of this loss is also lessened as it will be experienced slowly over time, with the death of an average of seven shortnose sturgeon adults or juveniles over a 27-year period.

A reduction in the number of shortnose sturgeon in the Delaware River would have the effect of reducing the amount of potential reproduction in this system as the fish killed would have no potential for future reproduction. However, it is estimated that on average, approximately 1/3 of adult females spawn in a particular year and approximately 1/2 of males spawn in a particular year. Given that the best available estimates indicate that there are more than 12,000 shortnose sturgeon in the Delaware River, it is reasonable to expect that there are at least 5,000 adults spawning in a particular year. It is unlikely that, in the worst case scenario, the loss of seven juvenile or adult shortnose sturgeon during the completed activities over a 27-year period would affect the success of spawning in any year. The small reduction in the number of male spawners (about half of the sturgeon killed by the proposed action if we assume a 50/50 sex ratio) is not expected to affect production of eggs as enough males will be present to fertilize eggs. Additionally, this small reduction in potential female spawners is expected to result in a small reduction in the number of eggs laid or larvae produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individuals that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be very small and would not change the stable trend of this population. Additionally, the proposed action will not adversely affect spawning habitat.

The proposed action is not likely to reduce distribution. While the action is likely to displace sturgeon within the dredge footprint and the area of the turbidity plume (up to 500 meters from the dredge) will temporarily affect the distribution of individual sturgeon, all of these changes in distribution will be temporary and limited to movements to relatively nearby areas. Continued vessel traffic and maintenance dredging may diminish the availability of prey in the access channel and turning basin of the proposed NJWP. However, this area represents a very small fraction of available foraging habitat within the river and we do not expect the reduction in available prey to limit prey available to sturgeon. We do not anticipate that any impacts to habitat will impact how sturgeon use the overall action area. As the number shortnose sturgeon likely to be killed as a result of the action as a whole is extremely small (adults and juveniles killed represent 0.06% of the Delaware River population), there is not likely to be a loss of any unique genetic haplotypes and it is unlikely to result in the loss of genetic diversity.

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

Based on the information provided above, the death of up to 7 shortnose sturgeon juveniles or adults over a 27-year period will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect shortnose sturgeon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, and it will not result in effects to the environment which would prevent shortnose sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter (i.e., it will not increase the risk of extinction faced by this species). This is the case because: given that: (1) the population trend of shortnose sturgeon in the Delaware River is stable; (2) the estimated mortality of seven shortnose sturgeon represents an extremely small percentage of the number of shortnose sturgeon in the Delaware River and an even smaller percentage of the species as a whole; (3) the loss of these shortnose sturgeon is likely to have such a small effect on reproductive output of the Delaware River population of shortnose sturgeon or the species as a whole that the loss of these shortnose sturgeon will not change the status or trends of the Delaware River population or the species as a whole; (4) the action will have only a minor and temporary consequence on the distribution of shortnose sturgeon in the action area (related to movements around the working dredge) and no consequence on the distribution of the species throughout its range; and, (5) the action will have no consequence on the ability of shortnose sturgeon to shelter and only an insignificant consequence 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 affect 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 action will have only insignificant consequences 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 where structures will be placed as part of the EFH mitigation plan, which together constitutes approximately only 0.3 percent of undisturbed bottom substrate within the saline portion of the tidal Delaware River. Impacts to habitat will be limited to the permanent conversion of one-acre of soft bottom substrate to hard substrate, temporary loss of forage within the dredge footprint, continued degradation of forage within the dredge footprint by propeller jet scour and maintenance dredging, the increases in suspended sediment during dredging and passage of vessels, and increased water depth; however, we do not anticipate any changes to substrate type (with the exception of the 1 acre discussed above) and the salinity regime. We do not anticipate that any impacts to habitat will affect 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.

11.2 Atlantic Sturgeon

As explained above, the proposed action is likely to result in the incidental take of up to 38 Atlantic sturgeon from the GOM, NYB, CB, and/or SA DPSs from 2022 through 2049 during cutterhed dredging in the Delaware River and as a result of vessel interactions. We expect that Atlantic sturgeon killed by dredging will be juveniles whereas vessel interaction will be with adults and subadults in addition to juveniles. No captures of eggs, larvae (yolk sac or post-yolk sac), or young of the year are anticipated. All other consequences to Atlantic sturgeon, including consequences from impacts to habitat and prey because of dredging, turbidity caused by in-water activities, and noise from pile driving will be insignificant or discountable.

1.1.1 Determination of DPS Composition

We have considered the best available information in order to determine from which DPSs adult individuals that will be killed are likely to have originated from.

We expect the proposed cutterhead dredging to kill up to two juvenile shortnose sturgeon, two juvenile Atlantic sturgeon, or one of each. All Atlantic sturgeon juveniles will be offspring from spawning in the Delaware River. Thus, any Atlantic sturgeon killed as a consequence of dredging will be of NYB DPS origin.

We expect that up to 35 Atlantic sturgeon will be killed by vessel strike during operation of the proposed NJWP. Of these, we estimate that up to 28 will be adults or sub-adult and up to seven to be juveniles. The juveniles will be of NYB DPS origin.

Using mixed stock analysis explained in section 5.2.2, we have determined that the adult Atlantic sturgeon killed by vessel strike related to this project to originate from the five DPSs at the following frequencies: 16 will originate from the New York Bight DPS, 5 from the Chesapeake Bay DPS, 5 from the South Atlantic DPS, and 2 from the Gulf of Maine DPS. Given the low numbers of Carolina DPS fish in the action area and the low number of mortalities anticipated, it is unlikely that there will be any mortality of any Carolina DPS Atlantic sturgeon.

- Up to 16 adult or sub-adult Atlantic sturgeon from NYB DPS
- Up to 5 adult or sub-adult Atlantic sturgeon from CB DPS
- Up to 5 adult or sub-adult Atlantic sturgeon from SA DPS
- Up to 2 adult or sub-adult Atlantic sturgeon from GOM DPS

In addition, we expect that one Atlantic sturgeon will be killed by vessel strike during construction of the NJWP. We expect this sturgeon to be either a juvenile or an adult Atlantic sturgeon of NYB DPS origin.

Given the above, we estimate the following lethal take from each Atlantic sturgeon DPS:

Table 35. Estimated total lethal take for Atlantic sturgeon from the proposed NJWP

DPS	Take
New York Bight	Up to 26
Chesapeake	Up to 5
South Atlantic	Up to 5
Gulf of Maine	Up to 2
Carolina	0

1.1.2 Gulf of Maine DPS

The GOM DPS is listed as threatened, and while Atlantic sturgeon occur in several rivers of the Gulf of Maine region, recent spawning has only been physically documented in the Kennebec River. That said, spawning is suspected to occur in the Androscoggin, Piscataqua, and Merrimack Rivers. Currently we do not have an estimate of the number of Atlantic sturgeon in any river nor is any currently available for the entire DPS; however, NEAMAP data indicates that the estimated ocean population of GOM DPS Atlantic sturgeon subadults and adults is 7,455 individuals. Gulf of Maine origin Atlantic sturgeon are subject to 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 ASMFC stock assessment concluded that the abundance of the Gulf of Maine DPS is “depleted” relative to historical levels. The Commission also noted that the Gulf of Maine is particularly data poor among all five DPSs. The assessment concluded that there is a 51 percent probability that the abundance of the Gulf of Maine DPS has increased since implementation of the 1998 fishing moratorium. The Commission also concluded that there is a relatively high likelihood (74 percent probability) that mortality for the Gulf of Maine DPS exceeds the mortality threshold used for the assessment ASMFC (2017). However, the Commission noted that there was considerable uncertainty related to these numbers, particularly concerning trends data for the Gulf of Maine DPS. For example, the stock assessment notes that it was not clear if: (1) the percent probability for the trend in abundance for the Gulf of Maine DPS is a reflection of the actual trend in abundance or of the underlying data quality for the DPS; and, (2) the percent probability that the Gulf of Maine DPS exceeds the mortality threshold actually reflects lower survival or was due to increased tagging model uncertainty owing to low sample sizes and potential emigration.

Here, we consider the consequences of the loss of up to two Atlantic sturgeon over a 27-year period from the GOM DPS (take is only anticipated during the 25 years of operation of the NJWP). The reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of up to two individuals over a 27-year period will have the consequence of reducing reproduction potential within the DPS because any dead GOM DPS Atlantic sturgeon has 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 consequence on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that is killed as a result of the proposed action, any consequence to future year classes is anticipated to be extremely small and would not change the status of this species. The proposed action will also not affect the spawning grounds within the rivers where GOM DPS fish spawn, because it will occur outside of those identified areas. Additionally, the action will not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by GOM DPS fish for the same reasons.

Because we do not have a population estimate for the GOM DPS, it is difficult to evaluate the consequences of mortality on this species caused by this action. However, because the proposed action will result in the loss of no more than two individuals over a 27-year period, or an average of 0.08 mortalities each year, it is unlikely that this death will have detectable consequences on the numbers and population trend of the GOM DPS.

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

Based on the information provided above, the death of up to two GOM DPS Atlantic sturgeon over a 27-year period, 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 maintaining a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring. Additionally, it will not result in consequences to the environment which prevent Atlantic sturgeon from completing their entire life cycle, including reproducing, sustenance, and shelter. This is the case because: (1) the death of two GOM DPS Atlantic sturgeon in any year will not change the status or trends of the species as a whole; (2) the loss of these two GOM DPS Atlantic sturgeon are not likely to have consequences on the levels of genetic heterogeneity in the population; (3) the action will have only a minor and temporary consequence on the distribution of GOM DPS Atlantic sturgeon in the action area and no consequence on the distribution of the species throughout its range; and, (4) the action will have no consequence on the ability of GOM DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging GOM DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the GOM DPS will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed action will affect the likelihood that the GOM DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the GOM DPS has been published at this time. As defined, a 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 species must have a sustained positive increasing population trend over time and an increase in population size. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (*i.e.*, spawning, foraging, resting) and must also have access to enough food. Next, we consider whether the proposed action will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed action to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number and overall distribution of GOM DPS Atlantic sturgeon. Any consequences to habitat will be insignificant and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed action will result in an extremely small amount of mortality over 27 years (two individuals) and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the action to affect the persistence of the GOM DPS of Atlantic sturgeon. The action will not change the status or trend of the GOM DPS of Atlantic sturgeon, nor will a very small reduction in numbers and future reproduction resulting from the proposed action reduce the likelihood of improvement in the status. The consequences of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The consequences of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which listing as threatened is no longer necessary. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual GOM DPS Atlantic sturgeon inside and outside of the action area, including the potential of increased vessel strikes discussed in the cumulative effects section, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to consequences related to the proposed action. We have considered the consequences of the proposed action in light of cumulative effects explained above, including climate changeand have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed action, resulting in the mortality of up to two GOM DPS Atlantic sturgeon over a 27-year period, is not likely to appreciably reduce the survival and recovery of the species.

1.1.3 New York Bight DPS

The NYB DPS is listed as endangered, and while Atlantic sturgeon occur in several rivers in the New York Bight, recent spawning has only been physically documented in the Hudson and Delaware Rivers. The essential physical features necessary to support spawning and recruitment are also present in the Connecticut and Housatonic Rivers (82 FR 39160; August 17, 2017). However, there is no current evidence that spawning is occurring nor are there studies underway to investigate spawning occurrence in those rivers; except one recent study where YOY fish of were captured in the Connecticut River (Savoy *et al.* 2017). Genetic analysis suggests that the YOY belonged to the SA DPS and at this time we do not know if these fish were the result of a single spawning event due to unique straying of the adults from the South Atlantic DPS's spawning rivers. Based on existing data, we expect any NYB DPS Atlantic sturgeon in the action area to originate from the Hudson or Delaware River.

There are no abundance estimates for the entire NYB DPS or for the entirety of either the Hudson or Delaware River spawning populations. There are, however, some abundance estimates for specific life stages (*e.g.*, natal juvenile abundance, spawning run abundance, and effective population size). Using side scan sonar technology in conjunction with detections of previously tagged Atlantic sturgeon, Kazyak *et al.* (2021, 2021) estimated the 2014 Hudson River spawning run size to be 466 sturgeon (95 percent CRI = 310-745). White *et al.* (in press) recently estimated the number of adults (N_S) in the Delaware River that successfully reproduced in order to create a cohort of offspring by using genetic pedigrees constructed from progeny genotypes. *Ns* estimates the number of successful breeders and is not synonymous with effective population size (Ne) or effective number of breeders (Nb) as these metrics describe genetic processes (e.g., inbreeding and genetic drift; Jamieson and Allendorf 2012, Waldman *et al.* 2019, Wang *et al.* 2016). White *et al.* (in press) estimated that *Ns* ranged from 42 (95% CI: 36-64) spawners in 2014 to 130 (95% CI: 116-138) spawners in 2017 during the years from 2013 to 2019. Because N_S only includes adults that generate at least one offspring during a single breeding season, it sets a lower bound on the size of the spawning run. Nevertheless, the genetics information indicates that at least 42 to 130 adults successfully contributed to the 2014- and 2017-year classes. White *et al.* (in press) concluded, when considering bias in the data when sample size of offspring is small may result in the Ns being underestimated, that the N_S for Delaware River Atlantic sturgeon is likely between 125 and 250.

The effective population size (*Ne*) measures the genetic behavior (inbreeding and genetic drift) of a stable population with a 50/50 sex ratio, random mating, and equal reproductive success among individuals (i.e. an idealized population). Thus, the *Ne* is not a population estimate but is used in conservation biology as a measure of the population's short- or long-term viability. Since the *Ne* is based on an 'idealized' population, the actual (census) population of reproductive individuals will usually, but not always, be larger than *Ne*. However, there is a general relationship between the size of the census population and the size of *Ne*. (White *et al.* 2021) found that the differences in estimated *Ne* between Atlantic sturgeon populations roughly corresponded to the differences in total population size. As such, the Hudson River has one of the largest estimates of *Ne* while Delaware River has one of the smallest estimates. Based on genetic analyses of two different life stages, subadults and natal juveniles, *Ne* for the Hudson River population has been estimated to be 198 (95 percent CI=171.7-230.7; (O'Leary *et al.* 2014)) and 156 (95 percent CI=138.3-176.1) (Waldman *et al.* 2019), while estimates for the Delaware River spawning population from the same studies are 108.7 (95 percent CI=74.7-186.1) (O'Leary *et al.* 2014) and 40 (95 percent CI=34.7-46.2) (Waldman *et al.* 2019).

The differences in estimated population size for the Hudson and Delaware River spawning populations and in *Ne* support the notion that the Hudson River spawning population is the more robust of the two spawning groups. This conclusion is further supported by genetic analyses that demonstrates Atlantic sturgeon originating from the Hudson River spawning population were more prevalent in mixed aggregations than sturgeon originating from the Delaware River spawning population, even when sampling occurred in areas and at times that targeted adults belonging to the Delaware River spawning population (2015a, Wirgin *et al.* 2015b). The Waldman *et al.* (2019) calculations of maximum effective population size, and comparison of these to four other spawning populations outside of the NYB DPS further supports our previous conclusion that the Delaware River spawning population is less robust than the Hudson River, which is likely the most robust of all of the U.S. Atlantic sturgeon spawning populations.

For this biological opinion, we have estimated adult and sub-adult abundance of the NYB DPS based on available information for the genetic composition and the estimated abundance of Atlantic sturgeon in marine waters (Damon-Randall *et al.* 2013, Kocik *et al.* 2013). At that time, we concluded that sub-adult and adult abundance of the NYB DPS was 34,566 sturgeon based upon the NEAMAP data. This number encompasses many age classes since sub-adults can be as young as two years old when they first enter the marine environment, and adults can live as long as 60 years (Hilton *et al.* 2016). For example, a study of Atlantic sturgeon captured in the geographic NYB determined that 742 of the Atlantic sturgeon captured represented 21 estimated age classes and that, individually, the sturgeon ranged in age from 2 to 35 years old (Dunton *et al.* 2016). The 2017 ASMFC stock assessment determined that abundance of the NYB DPS is "depleted" relative to historical levels (ASMFC 2017). The assessment also determined there is a relatively high probability (75 percent) that the NYB DPS abundance has increased since the implementation of the 1998 fishing moratorium, and a 31 percent probability that mortality for the NYB DPS exceeds the mortality threshold used for the assessment (ASMFC 2017). As discussed above, however, the Commission noted significant uncertainty in relation to the trend data. Moreover, new information suggests that the Commission's conclusions primarily reflect the status and trend of only the DPS's Hudson River spawning population.

NYB DPS origin Atlantic sturgeon are subject to numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. The largest single source of mortality appears to be capture as bycatch in commercial fisheries operating in the marine environment. Because early life stages and juveniles do not leave the river, they are not impacted by fisheries occurring in federal waters. Bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (the shad fishery) has now been closed and there is no indication that it will reopen soon. NYB DPS Atlantic sturgeon are killed as a result of other anthropogenic activities in the Hudson, Delaware, and other rivers within the NYB as well; sources of potential mortality include vessel strikes and entrainment in dredges.

We anticipate the mortality of up to 17 adult or sub-adult NYB DPS Atlantic sturgeon as a result of vessel interaction during the 27-year period. We also anticipate up to seven juvenile sturgeon vessel mortalities and up to two juvenile mortalities by entrainment in a cutterhead dredge. It is possible but highly unlikely that entrained fish in the cutterhead dredge could survive, and we assume here that these fish will be killed.

Here, we consider the consequences of the loss of up to 26 Atlantic sturgeon over a 27-year period (construction and operation of NJWP) from the NYB DPS. The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. Assuming a 50/50 sex ratio, the loss of up to 13 female sturgeon over a 27-year period will have the consequences of reducing reproduction potential, as any dead NYB DPS Atlantic sturgeon has no potential for future reproduction. However, this small reduction in potential future female spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, extremely small consequences on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by an individual that would be killed as a result of the proposed action, any consequences to future year classes is anticipated to be extremely small and would not change the status of this species. The proposed action will also not affect the spawning grounds within the rivers where NYB DPS fish spawn, as the action is not inclusive of spawning grounds. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by NYB DPS fish.

Because we do not have a total population estimate for the NYB DPS, it is difficult to evaluate the consequences of mortality on the species caused by this action. However, because the proposed action will result in the loss of no more than 26 individuals over a 27-year period, or an average of less than one per year, it is unlikely that these deaths will have detectable consequences on the abundance and population trend of the NYB DPS.

The proposed action is not likely to reduce distribution because the actions will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging grounds within the action area that may be used by NYB DPS subadults or adults. Further, the action is not expected to reduce the river-by-river distribution of Atlantic sturgeon. Any consequences to distribution will be minor and temporary and limited to the avoidance of the area where impacts of the action will occur.

Based on the information provided above, the death of up to 26 NYB DPS Atlantic sturgeon over a 27-year period will not appreciably reduce the likelihood of survival of the NYB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from maintaining a sufficient population represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring. It also will not result in consequences 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 these NYB DPS Atlantic sturgeon over a 27-year period represents an extremely small percentage of the species as a whole; (2) the death of these NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these NYB DPS Atlantic sturgeon is not likely to have consequences on the levels of genetic heterogeneity in the population; (4) the loss of these NYB DPS Atlantic sturgeon is likely to have such small consequences 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 consequence on the distribution of NYB DPS Atlantic sturgeon in the action area and no consequence on the distribution of the species throughout its range; and (6) the action will have no consequence on the ability of NYB DPS Atlantic sturgeon to shelter with only an insignificant consequence on individual foraging NYB DPS Atlantic sturgeon when considering that the footprint of the dredging and mitigating site is small relative to available forage within the lower estuary.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the NYB DPS will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed action will affect the likelihood that the NYB DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the NYB DPS has been published, at this time. As defined, the Recovery Plan will outline the steps necessary for recovery and the demographic criteria, which once attained, will allow the species to be delisted. We know that in general, to recover, a listed species must have a sustained positive population trend over time and an increase in population size. To allow that to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (*i.e.*, spawning, foraging, resting) and have access to enough food. Next, we consider whether this proposed action will affect the population size and/or trend in a way that will affect the likelihood of recovery.

The proposed action is not expected to modify, curtail or destroy the range of the species because it will result in an extremely small reduction in the number of NYB DPS Atlantic sturgeon and will not affect the overall distribution of NYB DPS Atlantic sturgeon. Any consequences to habitat will be insignificant and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also not limit forage to the species as ample forage exists to support the number of Atlantic sturgeon using the Delaware River estuary. The proposed action will result in a small amount of mortality (no more than 26 individuals over 27 years) and a subsequent small reduction in future reproductive output. For these reasons, the action is not expected to affect the persistence of the NYB DPS of Atlantic sturgeon. Additionally, the action will not change the status or population trend of the NYB DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed action will not reduce the likelihood of improvement in the status of the NYB DPS of Atlantic sturgeon. The consequences of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The consequences of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the 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.

Despite the threats faced by individual NYB DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to consequences related to the proposed action. We have considered the consequences of the proposed action in light of cumulative effects explained above, including climate change and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed action, resulting in the mortality of up to 26 NYB DPS Atlantic sturgeon over a 27-year period, is not likely to appreciably reduce the survival and recovery of this species.

1.1.4 Chesapeake Bay DPS

The CB DPS is listed as endangered and Atlantic sturgeon occur in and may potentially spawn in several rivers connected to the Chesapeake Bay. There is evidence of spawning in the James River (confirmed); Pamunkey River, a tributary of the York River; and Nanticoke River and its tributary Marshyhope Creek (section 5.2.2.4). In addition, detections of acoustically-tagged adult Atlantic sturgeon in the Mattaponi and Rappahannock Rivers during the spawning window have occurred. Historical evidence for these rivers as well as the Potomac River supports the likelihood that Atlantic sturgeon spawning populations are present in the Mattaponi, Rappahannock, and Potomac Rivers (NMFS 2017a).

Chesapeake Bay 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 no census nor enough information to establish a trend, for any life stage, for the James River spawning population, or for the DPS as a whole. However, the NEAMAP data indicates that the estimated ocean population of CB DPS Atlantic sturgeon is 8,811 sub-adult and adult individuals. The ASMFC (2017) stock assessment determined that abundance of the CB DPS is “depleted” relative to historical levels. The assessment, while noting significant uncertainty in trend data, also determined that there is a relatively low probability (36 percent) that abundance of the CB DPS has increased since the implementation of the 1998 fishing moratorium, and a 30 percent probability that mortality for the CB DPS exceeds the mortality threshold used for the assessment (ASMFC 2017).

We anticipate the mortality of up to five adult or sub-adult CB DPS Atlantic sturgeon as a result of vessel interactions during the 27-year period. Take of CB DPS is anticipated during the 25 years of operation of the NJWP. Thus, here, we consider the consequences of the loss of up to five Atlantic sturgeon over a 25-year period from 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 up to five individuals over a 25-year period will have the consequence of reducing the amount of reproduction potential as any dead CB DPS Atlantic sturgeon has 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, extremely small consequences on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by five CB DPS Atlantic sturgeon that could be killed as a result of the proposed action, any consequence to future year classes is anticipated to be extremely small and would not change the status of this species. The proposed action will also not affect the spawning grounds within the rivers where CB DPS fish spawn, as they are outside of the action area. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by CB DPS fish for the same reasons.

Because we do not have a population estimate for the CB DPS, it is difficult to evaluate the consequences of the mortality caused by this action on the species. However, because the proposed action will result in the loss of no more than five individual sturgeon over the 25 years of Port operation, or an average of 0.2 mortalities each year, it is unlikely that these deaths will have a detectable consequence on the abundance and population trend of the CB DPS.

The proposed action is not likely to reduce distribution of the CB DPS 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 consequences to distribution will be minor and temporary and limited to the avoidance of the area where impacts of the action occur.

Based on the information provided above, the death of up to five CB DPS Atlantic sturgeon over a 25 years of operating the Port, 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 maintaining a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring. It will also not result in consequences 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 up to five CB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (2) the loss of these CB DPS Atlantic sturgeon is not likely to have consequences on the levels of genetic heterogeneity in the population; (3) the action will have only a minor and temporary consequence on the distribution of CB DPS Atlantic sturgeon in the action area and no consequence on the distribution of the species throughout its range; and, (4) the action will have no consequence on the ability of CB DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging CB DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might appreciably reduce 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 the CB DPS will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed action will affect the likelihood that the CB DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the CB DPS has been published at this time. As defined, 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 population trend over time and an increase in population size. To allow that to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (*i.e.*, spawning, foraging, resting) and have access to enough food. Next, we consider whether the proposed action will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed action to modify, curtail or destroy the range of the species because it will result in an extremely small reduction in the number of CB DPS Atlantic sturgeon and it will not affect the overall distribution of CB DPS Atlantic sturgeon. Any consequences to habitat will be insignificant and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed action will result in an extremely small amount of mortality over the next 27 years and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the action to affect the persistence of the CB DPS of Atlantic sturgeon. This action will not change the status or trend of the CB DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed action will not reduce the likelihood of improvement in the status of the CB DPS of Atlantic sturgeon. The consequences of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The consequences of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the CB DPS 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.

Despite the threats faced by individual CB DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to consequences related to the proposed action. We have considered the consequences of the proposed action in light of cumulative effects explained above, climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed action, resulting in the mortality of up to five CB DPS Atlantic sturgeon over a 27 year period, is not likely to appreciably reduce the survival and recovery of this species.

1.1.5 South Atlantic DPS

The SA DPS is listed as endangered and Atlantic sturgeon originate from at least six rivers where spawning potentially still occurs. Secor (2002) estimates that 8,000 adult females were present in South Carolina prior to 1890. In Georgia, prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in Georgia prior to 1890. At the time of listing, only six spawning subpopulations were thought to have existed in the SA DPS: Combahee River, Edisto River, Savannah River, Ogeechee River, Altamaha River (including the Oconee and Ocmulgee tributaries), and the Satilla River. Three of the spawning subpopulations in the SA DPS are relatively robust and are considered the second (Altamaha River) and third (Combahee/Edisto River) largest spawning subpopulations across all five DPSs. Peterson *et al.* (2008) estimated the number of spawning adults in the Altamaha River was 324 (95 percent CI: 143-667) in 2004 and 386 (95 percent CI: 216-787) in 2005. Bahr and Peterson (2016) estimated the age-1 juvenile abundance in the Savannah River from 2013-2015 at 528 in 2013, 589 in 2014, and 597 in 2015. No census of the number of Atlantic sturgeon in any of the other spawning rivers or for the DPS as a whole is available. However, the NEAMAP data indicates that the estimated ocean population of SA DPS Atlantic sturgeon sub-adults and adults is 14,911 individuals.

The 2017 ASMFC stock assessment determined that abundance of the SA DPS is "depleted" relative to historical levels (ASMFC 2017). Due to a lack of suitable indices, the assessment was unable to determine the probability that the abundance of the SA DPS has increased since the implementation of the 1998 fishing moratorium. However, it was estimated that there is a 40 percent probability that mortality for the SA DPS exceeds the mortality threshold used for the assessment (ASMFC 2017).

We anticipate the mortality of up to five SA DPS adult or sub-adult Atlantic sturgeon as a result of the proposed project. Take of SA DPS is only anticipated during the 25 years of operation of the NJWP. Thus, here, we consider the consequences of the loss of up to five Atlantic sturgeon over a 25-year period from the SA DPS. The reproductive potential of the SA DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of up to five individual sturgeon over a 25-year period would have the consequence of reducing the amount of reproduction potential, as dead SA DPS Atlantic sturgeon 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 consequence on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by any individuals that are killed as a result of the proposed action, any consequence to future year classes is anticipated to be extremely small and will not change the status of this species. The proposed action will also not affect the spawning grounds within the rivers where SA DPS fish spawn because they are outside of the action area. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by SA DPS fish for the same reasons.

Because we do not have a population estimate for the SA DPS, it is difficult to evaluate the consequences of the mortality caused by this action on the species. However, because the proposed action will result in the loss of no more than five individuals over a 25-year period, or an average of 0.2 mortalities each year, it is unlikely that this death will have a detectable consequence on the numbers and population trend of the SA DPS.

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

Based on the information provided above, the death of up to five SA DPS Atlantic sturgeon over a 27-year period 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 maintaining 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 consequences to the environment which would prevent SA DPS Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of up to five SA DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (2) the loss of these five SA DPS Atlantic sturgeon is not likely to have consequences on the levels of genetic heterogeneity in the population; (3) the loss of these SA DPS Atlantic sturgeon over a 27-year period is likely to have such a small consequence on reproductive output that the loss of these individuals will not change the status or trends of the species; (4) the action will have only a minor and temporary consequence on the distribution of SA DPS Atlantic sturgeon in the action area and no consequence on the distribution of the species throughout its range; and, (5) the action will have no consequence on the ability of SA DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging SA DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, 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. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. No Recovery Plan for the SA DPS has been published at this time. As defined, 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 species must have a sustained positive population trend over time and an increase in population size. To allow that to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (*i.e.*, spawning, foraging, resting) and have access to enough food. Next, we consider whether the proposed action will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed action to modify, curtail or destroy the range of the species because it will result in an extremely small reduction in the number of SA DPS Atlantic sturgeon and it will not affect the overall distribution of SA DPS Atlantic sturgeon. Any consequences to habitat will be insignificant and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed action will result in an extremely small amount of mortality (up to five individuals) and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the action to affect the persistence of the SA DPS of Atlantic sturgeon. This action will not change the status or trend of the SA DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed action will not reduce the likelihood of improvement in the status of the SA DPS of Atlantic sturgeon. The consequences of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The consequences of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened or endangered. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual SA DPS Atlantic sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to consequences related to the proposed action. We have considered the consequences of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed action, resulting in the mortality of up to five SA DPS Atlantic sturgeon over a 25-year period, are not likely to appreciably reduce the survival and recovery of this species.

11.3 Delaware River Critical Habitat Unit (New York Bight DPS)

On August 27, 2019, NMFS and USFWS published a revised regulatory definition of "destruction or adverse modification" (84 FR 44976). Destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species." The "destruction or adverse modification" definition focuses on how federal actions affect the quantity and quality of the physical or biological features in the designated critical habitat for a listed species. Specifically, the Services will generally conclude that a federal action is likely to ''destroy or adversely modify'' designated critical habitat if the action results in an alteration of the quantity or quality of the essential physical or biological features of designated critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat as a whole for the conservation of the species.

As explained in section 9, we found the consequences to PBF 1, 3, and 4 to be either insignificant or extremely unlikely to occur. However, we did find that the proposed project is likely to adversely affect PBF 2. Placement of hard structures (one acre) associated with the compensatory mitigation plan, and initial dredging of the access channel, turning basin, and berth (85 acres) will occur within habitat we have identified as PBF 2. There will be a permanent loss of soft substrate by placement of the mitigation habitat structures and a two-year temporary significant loss of habitat within the dredge footprint during the construction of NJWP. We also anticipate that use of the NJWP channels by deep draft vessels and periodic maintenance dredging will continue to reduce the value of PBF 2 over the 25-year expected life-time of the NJWP operations. Thus, the proposed project will result in total loss or degradation of 86 acres of PBF 2 over a 27-year period (two years of construction and 25 years of operation).

As explained in section 9.2, this permanent and temporary loss and degradation of this soft bottom substrate between the river mouth and spawning sites necessary for juvenile foraging and physiological development, is an adverse consequence. Here, we consider whether the adverse consequence to PBF 2 in the action area results in a direct or indirect alteration of the critical habitat unit that appreciably diminishes the value of critical habitat as a whole for the conservation of the New York DPS of Atlantic sturgeon (i.e., we determine whether the proposed action is likely to result in the destruction or adverse modification of critical habitat). This analysis takes into account the geographic and temporal scope of the proposed action, recognizing that "functionality" of critical habitat necessarily means that it must now and must continue in the future to support the conservation of the species and progress toward recovery. The analysis takes into account any changes in amount, distribution, or characteristics of critical habitat over time essential to support the successful recovery of the species. Destruction or adverse modification does not depend strictly on the size or proportion of the area adversely affected, but rather on the role that the affected critical habitat serves with regard to the function of the critical habitat designation as a whole, and how that role is affected by the action.

We have not yet issued a recovery plan for Atlantic sturgeon. However, the 2018 Recovery Outline identifies a Recovery Vision, which identifies what we believe to be necessary for recovery as restated here (NMFS 2018):

> Subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future.

The conservation objective identified in the critical habitat designation is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment. Critical habitat has been designated for the New York Bight DPS in the Connecticut River, Housatonic, Hudson, and Delaware rivers. In the critical habitat designation, we determined that the protection of this habitat is necessary for the recovery of the New York Bight DPS. Here, we consider the loss and degradation of 86 acres of PBF 2 in the Delaware River critical habitat unit within the context of the conservation value provided by the critical habitat as a whole designated for the DPS, to determine if the alteration of this quantity of PBF 2 appreciably diminishes the value of critical habitat for the conservation of the species.

We have determined that the permanent loss of one acre, temporary loss of 85 acres, and the continued degradation of 85 acres in the Delaware River critical habitat unit will not appreciably diminish the value of critical habitat for the New York Bight DPS because:

(1) the amount of habitat lost is a very small proportion (0.52%) of the 29,430 acres of PBF 2 within the mesohaline zone of the Delaware River and less than 0.3 % of PBF 2 in the Delaware River critical habitat unit and an even smaller percentage of the amount of PBF 2 in the critical habitat designated for the New York Bight DPS. This small reduction is not expected to significantly limit forage or reduce the number of juveniles that can use the area for foraging and physiological development;

(2) the action will not impede the conservation objective identified in the critical habitat designation because it will not result in a reduction in the ability of successful physiological development or result in a reduction in the number of Atlantic sturgeon that could potentially recruit to the marine environment;

(3) the action will not interfere with the necessary conservation identified in the Recovery Vision; and,

(4) the consequences of the action are limited to the Delaware River critical habitat unit and will have no consequence on the value of critical habitat in the other units. Therefore, because the proposed action will not appreciably diminish the value of critical habitat for the conservation of the New York Bight DPS, it is not likely to result in the destruction or adverse modification of critical habitat designated for the New York Bight DPS of Atlantic sturgeon.

12 CONCLUSION

After reviewing the best available information regarding the status of endangered and threatened species under our jurisdiction, the environmental baseline for the action area, the consequences of the action, and the cumulative effects, it is our biological opinion that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon, the GOM, NYB, CB, and SA DPSs of Atlantic sturgeon. The proposed action may adversely affect, but is not likely to adversely modify or destroy critical habitat designated for the New York Bight DPS of Atlantic sturgeon.

13 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. “Fish and wildlife” is defined in the ESA “as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof” (16 U.S.C. § 1532(8)). “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by us to include any act that actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. “Otherwise lawful activities” are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR

19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA]." (16 U.S.C. 1538(g)). A "person" is defined in part as any entity subject to the jurisdiction of the U.S., including an individual, corporation, officer, employee, department, or instrument of the Federal government (see 16 U.S.C. § 1532(13)). Under the terms of ESA section 7(b)(4) and section 7(o)(2), taking that is incidental to, and not the purpose of carrying out an otherwise lawful activity is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this ITS. In issuing ITSs, NMFS takes no position on whether an action is an "otherwise lawful activity."

The USACE is proposing to issue a 10-year permit under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act to Public Service Enterprise Group (i.e., PSEG or Applicant) for construction of a marshalling facility (i.e., NJWP) in support of offshore wind projects off the coast of New Jersey and other U.S. East Coast states. The USACE will permit the in-water construction components of the Port's facilities as well as construction and maintenance dredging of the Port's access channel, turning basing, and berths. The USACE has indicated that they have authority to ensure compliance with RPMs and Terms and Conditions related to the dredging and pile driving during construction of the NJWP.

During operation of the Port, vessels delivering wind turbine components and vessels transporting assembled turbines will call at the Port. Because the specific offshore wind projects the Port will service are not known at this time, we cannot say to what lease sites the vessels will travel during operation of the Port, or from where the delivery vessels will originate. However, we can say that vessels will have to travel between the pilot area at the mouth of Delaware Bay to and from the Port site. As a result, we are reasonably certain that vessels traveling between the NJWP and the mouth of the Delaware Bay will cause vessel strike mortalities of Atlantic sturgeon and shortnose sturgeon.

Because the anticipated vessel strike mortalities of sturgeon occur as a result of the USACE permit, all associated mortalities are considered "incidental take" for purposes of this biological opinion (see 50 CFR §402.02). While the USACE does not have authority over the long-term operation of the Port or vessels calling at the Port after it has been constructed, the long-term use and traffic of the Port by vessels would not occur but for the issuance of the permit. Thus, any vessel strikes by vessels calling at the Port would be a consequence of activities directly resulting from the proposed action. The USACE has indicated that they have authority to ensure compliance with RPMs and Terms and Conditions related to collecting data about the number of vessels calling at the NJWP during its operations. The Port owner/operator, does have authority over vessels as they travel through the access channel to and from the NJWP itself. They also have authority over operation of the Port and number of vessel calls. As such, the "applicant only" RPMs and Terms and Conditions, necessary and appropriate to monitor incidental take resulting from the expected 25 years of operation of the NJWP are the responsibility of the owner/operator of the Port. To the extent the USACE exercises its authority in the form of permit conditions related to the construction, operation and/or future maintenance of Port facilities, the USACE has responsibility for compliance with the RPMs and Terms and Conditions.

An incidental take statement (ITS) exempts action agencies and their permittees from the ESA's section 9 penalties and prohibitions if they comply with the RPMs and the implementing terms and conditions of the ITS. An ITS must specify the amount or extent of any incidental taking of endangered or threatened species. When we exempt incidental take, we must issue RPMs and Terms and Conditions to minimize/avoid (either the amount or the effect of that take, that is, the RPMs could reduce the number of takes or could minimize the potential for mortality of captured animals) and monitor take. The measures described below are non-discretionary, and must be undertaken by the USACE and the Port owner/ operator so that they become binding conditions for the exemption in section 7(o)(2) to apply. The USACE has a continuing duty to regulate the activity covered by this ITS. If the USACE (1) fails to assume and implement the terms and conditions or (2) fails to require any permittee, contractors and personnel to adhere to the terms and conditions of the ITS through enforceable terms that are added to contracts or other documents as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USACE and the Port owner/ operator must report on the progress of the action and its impact on ESA-listed species to NMFS GARFO PRD as specified in the ITS [50 CFR §402.14(i)(3)] (See U.S. FWS and NMFS's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

13.1 Anticipated Amount or Extent of Incidental Take

The proposed action has the potential to result in the mortality of shortnose sturgeon and NYB Atlantic sturgeon from entrainment in cutterhead dredge and vessel strike by construction vessels. We also anticipate that the long-term operation of the NJWP will cause vessel strikes of Atlantic sturgeon NYB, GOM, CB, and SA DPSs as well as shortnose sturgeon.

Take over the Life Span of the NJWP

Take incidental to the proposed action and activities caused by the proposed project is outlined below. Incidental take from the Port's construction as well as vessel activities during operation of the Port would not occur but for the proposed project. Vessel strike of listed species would be a consequence of vessel activities that are caused by the proposed action, and vessel strikes are reasonably certain to occur based on what we know about sturgeon biology and movement within the Delaware River and Bay, data on vessel traffic within the action area, and information on vessel traffic and sturgeon interactions.

Table 36. Total exempted incidental lethal take resulting from construction and maintenance dredging, vessel strikes by construction vessels, and vessel strikes during the long-term operation of the NJWP.

Species	Lethal
Shortnose Sturgeon	**Up to 7**
Atlantic Sturgeon	**Up to 38**

Sturgeon Take Incidental to Construction and Maintenance Cutterhead Dredging of the Port and Access Channel

We expect cutterhead dredging to kill up to two (2) sturgeon. These may be two juvenile shortnose sturgeon, two juvenile NYB DPS Atlantic sturgeon, or one of each.

Sturgeon Take Incidental from Vessel Traffic During Port Construction

We expect that sturgeon interacting with construction vessels during construction of the NJWP will result in the mortality of one (1) shortnose sturgeon and one (1) Atlantic sturgeon. The shortnose sturgeon may be a juvenile or an adult. The Atlantic sturgeon will be either a juvenile or an adult of the NYB DPS.

Sturgeon Take Incidental from Vessel Traffic During Long-term Operation

We expect up to 39 lethal vessel strikes during operation of the NJWP. Of these:

- Up to 4 shortnose sturgeon juveniles, adults, or mix of the two
- Up to 7 juvenile Atlantic sturgeon from NYB DPS
- Up to 16 adult Atlantic sturgeon from NYB DPS
- Up to 5 adult Atlantic sturgeon from CB DPS
- Up to 5 adult Atlantic sturgeon from SA DPS
- Up to 2 adult Atlantic sturgeon from GOM DPS

Summary Total Incidental Take

This level of take (up to 7 shortnose sturgeon and up to 38 Atlantic sturgeon) is expected to occur over the entire period that comprises the life of the project and operation of the NJWP *e.g.*, from 2022 through 2049, and is not likely to jeopardize the continued existence of listed species.

This incidental take is for the whole period of operation and the RPMs and TCs applies to the USACE proposed issuance of a permit and any subsequent permit issued for maintenance. The ITS incorporates the incidental take summarized above and the RPMs and TCs and take exemption would be operative upon issuance of a subsequent permit. In the absence of a permit, the applicant is responsible for providing the information.

13.2 Monitoring Incidental Take by Vessel Strike

In the Consequences of the Action, section 8.5, we analyze the consequences of vessel activities that are caused by the proposed action. We anticipate that interaction with vessels traveling to and from the NJWP will result in incidental lethal take of shortnose sturgeon and Atlantic sturgeon. In our analysis, we estimate the number of vessel strike mortalities occurring during operation of the terminal based on the anticipated annual number of vessel calls at the NJWP. Based on this analysis, we estimate that vessels calling at the NJWP and associated support tugs will cause 35 Atlantic sturgeon and four shortnose sturgeon vessel strike mortalities over a 25-year period. We also estimated that vessel traffic during the two years of constructing the NJWP would result in construction vessels killing one Atlantic sturgeon and one shortnose sturgeon. However, in all or the majority of cases, it is not possible to document vessel strikes as they are unlikely to be observed. Carcasses are occasionally found floating in the river or along the shorelines, and state biologists may collect these carcasses and determine the cause of mortality (e.g., whether it was likely to be a vessel strike mortality). However, under most circumstances, when a sturgeon carcass is found and determined to be a vessel strike mortality, it is impossible to determine which vessel was involved in the incident.

As explained in the Consequences of the Action, we anticipate that on average one Atlantic sturgeon will be killed for every 898 vessel trips and a shortnose sturgeon for every 9,430 vessel trips. This estimate provides a surrogate for monitoring the amount of incidental take during operation of the NJWP. Therefore, in discussions with the USACE and PSEG, we concluded that incidental take associated with operation of the NJWP can be monitored by the USACE reporting the annual number of vessel calls at the NJWP. This will be used as the primary method of determining the amount of incidental take and whether it has been exceeded. Specifically, we will consider that one Atlantic sturgeon has been taken for every 898 vessel trips and one shortnose sturgeon for every 9,430 vessel trips. A few vessel strikes have been directly observed within the Delaware River and Bay, and there is a possibility that an Atlantic sturgeon or shortnose sturgeon vessel strike can be associated with a particular vessel. In those cases, the vessel strike mortality will be included in (i.e. not in addition to) the number of vessel strikes that are based on number of vessel calls at the NJWP.

We also conclude in the Consequences of the Action section that vessel activity during construction of the proposed port and maintenance dredging of the access channel will increase the risk of vessel strike in the river channel off Artificial Island and in the Federal Navigation Channel between the NJWP site and Trenton, NJ. We similarly based the estimated take on anticipated number of vessel trips that will occur each of the two years of construction. The number of vessels delivering construction materials, tugs supporting construction of the structures (e.g., pile driving), and the tugs supporting dredging operations (two trips per dredging period: one-way trip to the proposed Port site and again during the one one-way trip departing the proposed Port site) can be recorded and tracked as a proxy for take. Further, the PSEG monitor take of sturgeon at the cooling water intakes for the power plants, and they collect and report any sturgeon that are impinged on the trash racks. Some of these sturgeon are dead or injured prior to being impinged with signs of having being hit by a propeller. Collection of vessel struck sturgeon mortalities at the cooling water intake may overlap in time with NJWP construction and dredging activities. Thus, we may consider any collection of dead sturgeon at the cooling water intakes killed by vessel activity associated with construction or dredging activities if these occur close in time. If, based on such considerations, we conclude that construction or maintenance dredging activities caused sturgeon mortalities, then we will add these mortalities to the take estimated from number of vessel trips during construction.

As soon as the estimated total number of shortnose sturgeon or Atlantic sturgeon that are observed and believed to have been taken equals the allowable take threshold (*e.g.*, if the total was 38 Atlantic sturgeon: 38 takes via surrogate or two observed in the dredge spoil and 36 via surrogate, etc.),

- any additional vessel call,
- any additional observed take, or

- any sturgeon mortalities at the PSEG trash rack that is counted as caused by project activities will be considered to exceed the exempted level of take.

13.3 Reasonable and Prudent Measures, Terms and Conditions, and Justifications

The following RPMs found in Table 37 are necessary and appropriate to minimize, avoid, and monitor impacts of incidental take resulting from the proposed action. In order to be exempt from prohibitions of section 9 of the ESA, you must comply with the following terms and conditions found in Table 37, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

The RPMs, with their implementing terms and conditions, are designed to avoid and minimize take, and monitor the impact of incidental take that might otherwise result from the proposed action. Specifically, these RPMs and Terms and Conditions will keep us informed of the number of Port related vessel trips and when and where dredging activities are taking place and will require the USACE to report any take in a reasonable amount of time. Additionally, you must implement measures to monitor for entrainment during dredging and the number of sturgeon mortalities from vessel strikes. The third column below explains why each of these RPMs and Terms and Conditions are necessary and appropriate to avoid or minimize and/or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the action as proposed by USACE.

Table 37. Reasonable and Prudent Measures and Terms & Conditions applicable to the USACE and the Applicant. Referenced forms and documents can be found on the NOAA GARFO website at URL https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-take-reporting-programmatics

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
RPMs Applicable to Vessel Traffic		
1. USACE shall track number of vessel calls at the NJWP to estimate take of sturgeon to assure that take is not exceeded.	1. During construction of the NJWP, USACE shall report to us on an annual basis the number of times vessels delivered construction materials from upstream contractor yards, the number of tugs that supported construction of facilities, and the number of tugs that supported dredging activities during each dredging period. The first report shall cover the period from the first construction start date until end of the work window on March 15, 2023. The second report shall cover the period from March 15, 2023, to March 15, 2024. USACE shall provide the reports to us by April 15, 2023, and April 15, 2024. If construction is not completed by March 15, 2024, then USACE shall provide a report for the remaining construction period once the construction is completed and no later than April 15, 2025. By the due dates set above, USACE shall contact us at incidental.take@noaa.gove to provide us with: a. The number of vessels that arrived at the project site with construction materials during each period as describe above. b. If deliveries occurred in batches, then USACE shall provide us with the months the deliveries occurred and number of deliveries during each period.	This RPM and these TCs are necessary and appropriate because we used an estimate of sturgeon vessel strike mortalities per vessel trip to calculate take. The RPM and TC serve to ensure that we can monitor the level of take associated with the proposed action. They are necessary because they serve to ensure that we are aware of the months when vessel activity occurs, which will allow us to evaluate the threat of vessel strikes during Atlantic sturgeon spawning migrations. It will also allow us to compare impingement or collection of sturgeon at the trash bars and traveling screens of the Salem and Hope Creek Generating Stations located just downstream of the Port site. This is only a minor change because it is not expected to result in any delay to the project, result in any additional cost, and will merely involve occasional e-mails between the Applicant or Port owner/operator and USACE and our staff.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	c. The number of tugs at the Port that are supporting the construction of the facilities (e.g. the quay and cable protective wall) d. The number of tugs during each dredge period that supported dredging activities. 2. Until the end of operations of the NJWP and not to exceed 25 years, at the beginning of each calendar year and no later than March 1, the USACE during the life of the permit (NAP-2019-01084-39) and any subsequent permits related to the Port, or in the event that there is no USACE permit in effect, then the Applicant/ port owner/operator shall contact us at incidental.take@noaa.gove to provide us with: a. The total number of vessel calls at the NJWP the previous year b. The number of vessels that called at the NJWP by month c. Type of vessels and their drafts that called at the NJWP The correspondence must reference the name of the project (i.e. NJ Wind Port) and our file number (GARFO-2021-02227). If the permit is renewed, USACE shall contact us to discuss this RPM and TC. We shall have the final say in determining if the take should count towards the Incidental Take Statement.	

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
RPMs Applicable for All Activities		
2. We must be contacted prior to the commencement of dredging and again upon completion of the dredging activity.	3. USACE must contact us at incidental.take@noaa.gov 3 days before the commencement of each dredging activity and again within 3 days of the completion of the activity. This correspondence will serve both to alert us of the commencement and cessation of dredging activities and to give us an opportunity to provide USACE with any updated contact information or reporting forms. At the start of dredging activities, USACE must include the total volume and area that is anticipated will be removed, the area where dredging will occur (access channel, turning basin, or berths), and the type of dredge to be used. At the end of the dredging event, USACE must report to us the actual volume and area removed, location where dredging occurred (with RKMs), and the equipment used (type of dredge).	This RPM and TC is necessary and appropriate because it serves to ensure that we are aware of the dates and locations of all dredging that may result in take. This will allow us to monitor the duration and seasonality of dredging activities as well as give us an opportunity to provide USACE with any updated species information or contact information for our staff. This is only a minor change because it is not expected to result in any delay to the project, result in any additional cost and will merely involve occasional e-mails between USACE and our staff.
3. All sturgeon captures, injuries, or mortalities in the immediate activity area must be reported to us within 24 hours.	4. In the event of any captures or entrainment of shortnose sturgeon or Atlantic sturgeon (lethal or non-lethal), USACE must ensure that the Applicant follows the Sturgeon Take Standard Operating Procedures (SOPs) that can be downloaded from our website **(https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-consultations-greater-atlantic-region)** USACE must submit a completed Take Report Form for ESA-Listed Species within 24 hours of any take. **The form can be**	This RPM and these TCs are necessary and appropriate to ensure the documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. In some cases, when the cause of death is uncertain, a necropsy may be necessary to aid in the determination of whether or not a mortality should count toward the ITS. This is essential for monitoring the level of incidental take associated with the proposed action. These RPMs and TCs

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	downloaded from our website. The completed Take Report Forms, together with any supporting photos or videos must be submitted to incidental.take@noaa.gov with "Take Report Form" in the subject line. 5. In the event of any lethal takes of shortnose sturgeon or Atlantic sturgeon, any dead specimens or body parts must be photographed, measured, and preserved (refrigerated, not frozen) until disposal procedures are discussed with us. 6. During construction of the NJWP, USACE shall notify us of any suspected sturgeon vessel strikes or dredging mortalities found in the trash rack of the Salem and Hope Creek Generating Stations. The Applicant shall provide to the USACE the number of and the date the sturgeon was impinged on the trash rack or otherwise found, species of the sturgeon, size of the sturgeon, description of injuries, and any other pertinent information such as, for instance, observation of eggs. USACE must also notify us if dead or injured sturgeon are observed and collected within the NJWP Project Area or along the shores of Artificial Island. The Applicant shall provide the information to the USACE as soon as it is available to the Applicant. We shall have the final say in determining if the take should count towards the Incidental Take Statement.	represent only a minor change as compliance will not delay of the project, result in any additional cost, or decrease in the efficiency of the dredging operations.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
4. Any dead sturgeon must be held until proper disposal procedures can be discussed with us. The fish should be held in cold storage.	7. In the event a dead sturgeon is collected or captured (e.g., dead sturgeon incidentally collected during dredging in the action area) and USACE request concurrence that this take should not be attributed to the Incidental Take Statement but we do not concur, or if it cannot be determined whether a proposed activity was the cause of death, then the dead sturgeon must be transferred to an appropriately permitted research facility identified by us so that a necropsy can be undertaken to attempt to determine the cause of death. NMFS will have the mortality assigned to the incidental take statement if the necropsy determines that the death was due to injuries sustained from an interaction with dredge gear. We shall have the final say in determining if the take should count towards the Incidental Take Statement.	These RPMs and TCs are necessary and appropriate to ensure the documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. In some cases, when the cause of death is uncertain, a necropsy may be necessary to aid in the determination of whether or not a mortality should count toward the ITS. This is essential for monitoring the level of incidental take associated with the proposed action. These RPMs and TCs represent only a minor change as compliance will not result in any increased cost, delay of the project or decrease in the efficiency of the dredging operations
3. All Atlantic sturgeon over 75 cm total length that are captured or found dead within the project area and are believed to have interacted with a dredge must have a fin clip taken for genetic analysis. This sample must be transferred to a NMFS-approved laboratory capable of performing the genetic analysis.	8. USACE must ensure that fin clips are taken according to the procedure outlined in the “Procedure for Obtaining Sturgeon Fin Clips” found on our website. The fin clips shall be sent to a NMFS approved laboratory capable of performing genetic analysis. Fin clips must be taken prior to preservation of other fish parts or whole bodies. To the extent authorized by law, you are responsible for the cost of the genetic analysis.	This RPM and this TC is necessary and appropriate to ensure the proper handling and documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. This is essential for monitoring the level of incidental take associated with the proposed action. Genetic analysis must be conducted on Atlantic sturgeon samples to determine the appropriate DPS of origin and accurately record take of this species. This RPM and

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
		TC represent only a minor change as compliance will not result in delay of the project or decrease in the efficiency of the dredging operations. The RPM and TC will only result in a minor cost to the project and will not significantly increase in the cost of the project, as the cost of genetic analysis is extremely small relative to the cost of the project.
RPMs Applicable for All Dredge Activities		
4. USACE shall assure that all monitoring, animal handling, and reporting procedures are followed and all reporting is carried out in a timely manner.	• USACE shall make sure that all vessels or dredges have the latest documents describing the responsibilities of crew and observes to monitor for take of listed species, instructions of what to do if take occurs, and the latest updated take forms. In addition, you shall ensure that observers and crew are provided with the USACE contact information for report of take. Contracted observers and crew shall be informed where these documents are located on the vessel or dredge. Documents and forms that shall be available on vessels or dredges include: • Standard Operation Procedures for take of sturgeon • Take Report Form for ESA Listed Species • Procedure for Obtaining Sturgeon Fin Clips • Sturgeon Genetic Sampling Submission Form • Dredge Observer Form • Monitoring Specifications for Dredges (These forms can be found on our website at URL https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-take-reporting-programmatics)	These RPMs and TCs are necessary and appropriate because they serve to ensure that monitoring is properly carried out and the timely reporting of take so that we are aware of the dates and locations of take. Availability of documents detailing procedures for handling of live animals can reduce the chance that handling will cause injury and proper handling of injured animals assures that the effects from the injury are minimized.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
5. We must be contacted prior to the commencement of dredging and again upon completion of the dredging activity.	1. USACE must contact us at incidental.take@noaa.gov 3 days before the commencement of each dredging activity and again within 3 days of the completion of the activity. The correspondence must reference the name of the project (i.e. NJ Wind Port) and our file number (GARFO-2021-02227). This correspondence will serve both to alert us of the commencement and cessation of dredging activities and to give us an opportunity to provide USACE with any updated contact information or reporting forms. At the start of dredging activities, you must include the total volume and area that is anticipated being removed and the type of dredge to be used. At the end of the dredging event, USACE must report to us the actual volume removed and acreage dredged, and the equipment used (type of dredge).	These RPMs and TCs are necessary and appropriate because they serve to ensure that we are aware of the dates and locations of all dredging that may result in take. This will allow us to monitor the duration and seasonality of dredging activities as well as give us an opportunity to provide USACE with any updated species information or contact information for our staff. This is only a minor change because it is not expected to result in any delay to the project, or any increase in cost and will merely involve occasional e-mails between USACE and our staff.
RPMs for Cutterhead Dredge		
6. Prior to finalizing contract specifications and initiating contract solicitation processes for new cutterhead dredging projects, USACE must work with us to develop monitoring plans for cutterhead dredges and/or dredged material disposal sites.	9. USACE will meet with us prior to finalizing contract specifications and initiating contract solicitation processes for new cutterhead dredging projects to determine the scope of a monitoring plan. This monitoring plan must be agreed to by us prior to initiation of contracting processes and must be implemented in all subsequent cutterhead dredge contracts, unless modified by agreement of USACE and NMFS. The goal of the monitoring plan will be to accurately determine entrainment of shortnose sturgeon and Atlantic sturgeon in future cutterhead dredging projects; however, physical	These RPMs and TCs are necessary and appropriate as they serve to ensure that sturgeon have a minimized risk of injury or mortality from cutterhead dredging activities. The monitoring plan represents only a minor change as it will not result in any significant delays to dredging or significant modifications of the dredge plan and any increased cost will be very small in comparison to the total costs of the project or changes to dredging operations.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	screening of dredge material by observers is not required.	
RPMs for Mechanical Dredging		
7. A lookout/bridge watch must be present to observe all mechanical dredging activities where dredged material will be deposited for any capture of sturgeon.	10. For mechanical dredging USACE must require a lookout to watch for captured sturgeon in the dredge bucket and to monitor the scow/hopper for sturgeon. Any interactions with sturgeon must be reported to us.	These RPMs and TCs are necessary and appropriate because they require that USACE have sufficient observer coverage to ensure the detection of any interactions with listed species. This is necessary for the monitoring of the level of take associated with the proposed action. The inclusion of these RPMs and TCs is only a minor change as USACE included some level of observer coverage in the original project description and the increase in coverage (i.e., the addition of any months/activities that were not previously subject to observer coverage) will represent only a small increase in the cost of the project and will not result in any delays. These also represent only a minor change as in many instances they serve to clarify the duties of the inspectors or observers and will not result in any additional cost to the project.
8. You must ensure that all measures are taken to protect any sturgeon that survives capture in the mechanical dredge.	11. Any sturgeon observed in the dredge scow/hopper during mechanical dredging operations must be removed with a net and, if alive, returned to the water away from the dredge site. See our Sturgeon Resuscitation Guidance on our website (https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-take-reporting-programmatics-greater-atlantic)	These RPMs and TCs are necessary and appropriate to ensure that any sturgeon that survive capture in a mechanical dredge are given the maximum probability of remaining alive and not suffering additional injury or subsequent mortality through inappropriate handling. This represents only a minor change as following these procedures will not result in an increase in cost or any delays to the proposed project.

14 CONSERVATION RECOMMENDATIONS

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

(1) USACE should support studies that provide information on effects to Atlantic sturgeon rearing and foraging habitat from dredging and follow up studies to assess if Atlantic sturgeon use of those areas have changed.
(2) USACE should continue to support studies of Atlantic and shortnose sturgeon spawning locations in the Delaware River, behavior and spatial occurrence of early life stages, life stage duration, and other information that may allow refinement of dredging activities and timeframes. This information could be used to explore the possibility of developing measures to avoid and minimize effects to spawning, eggs, yolk-sac larvae, and post yolk-sac larvae.
(3) Population estimates are lacking for Atlantic sturgeon. USACE should continue to support studies to assist in gathering the necessary information to develop a population estimate for the NYB DPS.
(4) USACE should conduct studies at the upland dredged material disposal areas to assess the potential for improved screening to: (1) establish the type and size of biological material that may be entrained in the cutterhead dredge, and (2) verify that monitoring the disposal site without screening is providing an accurate assessment of entrained material.
(5) USACE should support efforts to report and keep track of sturgeon carcasses 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 the procedures for reporting and keeping track of observations of sturgeon carcasses.

15 REINITIATION OF CONSULTATION

This concludes formal consultation on your proposal to issue a 10-year Section 10/404 Individual Permit to PSEG associated with construction of the New Jersey Wind Port. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately.

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