NATIONAL MARINE FISHERIES SERVICE

ENDANGERED SPECIES ACT

BIOLOGICAL OPINION

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

Activity Considered: USACE Permit for the Edgemoor Container Port (NAP-2019-278-23)

GARFO-2022-03516

Conducted by: National Marine Fisheries Service

Greater Atlantic Regional Fisheries Office

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1 INTRODUCTION

This constitutes the reinitiated biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of construction and operation of the Edgemoor Container Port (Port). The applicant, Diamond State Port Corporation (DSPC or applicant), proposes to construct a new shipping container port facility on a site formerly occupied by the Chemours (DuPont) Edge Moor Plant along the Delaware River in Edgemoor, New Castle County, Delaware. DSPC applied to the U.S. Army Corps of Engineers (USACE), Philadelphia District, for permits pursuant to Section 404 of the Clean Water Act (CWA) and Section 10 of the Rivers and Harbors Act of 1899, to discharge fill material and to conduct dredging and disposal activities within, and adjacent to, navigable waters of the United States at the proposed Port. During the previous consultation, the applicant indicated that they entered into a 50-year Concession Agreement with GT USA for the operation of the Port; therefore, in this Opinion, we consider the likely consequences of the proposed action 53 years from when construction starts (up to 3 years of construction plus 50 years of operation). On August 4, 2022, the USACE issued a permit for the proposed action, but has subsequently informed us that the applicant has not started in-water work.

The project involves both in-water and on-land activities to re-develop the property into a multi-user containerized cargo port capable of accepting New Panamax cargo ships. 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 the loss of approximately 87 acres of benthic habitat within the dredge footprint. The previous Opinion was based on the description of the consequences of the proposed action on ESA-listed species and critical habitat that the USACE in the Biological Assessment (BA) enclosed with their letter dated October 25, 2021, which was the initiation date of the earlier consultation.

Subsequent to completing consultation, the Northeast Fisheries Science Center (NEFSC) completed review of a sturgeon carcass database maintained by the New Jersey Fish and Wildlife (NJFW) (Report finalized March 29, 2023). Their review concluded that the reported carcasses included in the NJFW database were additional mortalities beyond the observed mortalities reported in another database maintained by the Delaware Department of Natural Resources and Environmental Control (DNREC). For the previous Opinion, we had relied on the DNREC data to estimate the risk of vessel strike. In their review, the NEFSC also suggested that incorporating the additional NJFW reported mortalities into the DNREC reported mortalities would increase the calculated risk of a vessel striking and killing a sturgeon. Based on this, we concluded that the NJFW data constituted new information, which revealed that the action may affect listed species in a manner and/or to an extent not previously considered in the current biological opinion and, therefore, the consultation needed to be reinitiated per the ESA implementing regulations at 50 CFR 402.16. This reinitiated Opinion is based on the description of the project activities as they are described in the USACE August 4, 2022 permit, as well as the effects of the proposed action on ESA-listed species and critical habitat that the USACE provided in their Biological Assessment (BA) on October 21, 2022. The analysis, along with scientific literature and other sources of information as cited in the references section also contribute to the basis of this Opinion.

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the District Court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and out of an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

2 ESA CONSULTATION HISTORY

August 2019 through September 2022

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.

October 2021

On October 25, 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.

November 2021

On November 17, we sent an email to the USACE with an electronic copy of a letter dated November 17, 2021, initiating formal consultation. The initiation date was set to October 25, 2021, when we received the request with adequate information to initiate formal consultation.

March 2022

We completed the biological opinion on March 30, 2022. The signed biological opinion and transmittal letter were sent via email to the USACE on March 31, 2022. A complete administrative record of this consultation is kept at the NMFS Greater Atlantic Regional Fisheries Office.

September 2022

The NEFSC conducted a review of a sturgeon carcass database maintained by the New Jersey Fish and Wildlife Department. Based on this review, we concluded that the data constituted new information that reveals that the action may affect listed species in a manner and/or to an extent not previously considered in the current biological opinion and, therefore, the consultation needed to be reinitiated per the ESA implementing regulations at 50 CFR 402.16. A complete administrative record of this consultation will be kept at our NMFS Greater Atlantic Regional Fisheries Office.

3 PROJECT DESCRIPTION

The project includes the construction of the Port, the operation of the Port, and the implementation of a mitigation plan. The components of the project site relative to the Port are: the area directly affected by construction of the wharf ("Construction Area") (5.5 acres), the dredging activities ("Dredging Area") (86.9 acres), and the mitigation site ("Mitigation Area") (1.1 acres). Each of these three components and their related activities are described below.

3.1 Site Location

The proposed Port will be located at 4600 Hay Road in the Edgemoor section of unincorporated New Castle County, Delaware, along the eastern shore of the Delaware River. Latitude/Longitude: 39.74825° N/75.496028° W (NAD 83) and approximately from River Kilometer (RKM) 117 to RKM 118 (River Mile (RM) 72.5 to RM 73.3).

3.2 Port Facilities and Structures

The proposed Port includes the construction of the wharf structure integrated with a site retention system along the wharf, the extension and termination of the site retention system at each end of the site, and the filling of the space between the retention system and mean high water (MHW).

The proposed Port also includes dredging of the river bottom along the Delaware River between the Federal Navigation Channel and the Port and the construction of harbor access and berthing areas along the port facility. The harbor access is proposed to include the construction of a 518 m (1,700 ft) diameter turning basin at the downstream portion of the project sufficient for the largest design ship expected to use the facility, a 12,000 twenty-foot equivalent unit (TEU) container ship. The turning basin is inclusive of the Delaware River Federal Navigation Channel, with the harbor extending approximately 305 m (1,000 ft) landward from the project-side edge of the channel.

The Port's harbor will be constructed with a flat bottom corresponding to a maintained depth of -13.7 m (-45 ft) mean low water (MLW) consistent with the maintained depths of the Federal Navigation Channel and is proposed to cover an area of 64.5 acres. The transitions into the harbor from the upriver and downriver subaqueous slopes are to be dredged to a 6 horizontal to 1 vertical slope, and a 3 horizontal to 1 vertical slope is proposed along the shore from the base of the sheet pile wall to the front of the wharf for a total area of 86.9[1] acres of dredging footprint. This grading profile results in a total dredge (excavation) volume of approximately 3.3 million cubic yards (cy) of material.

3.3 Construction of Facility Structures

The Port will be constructed over an approximately 3-year period, with the schedules for wharf construction activities sequenced with that for dredging. Year 1 of construction is proposed to include demolition of existing in-water structures in the foot-print of the project, construction of the proposed sheet pile retaining wall, the placement of clean borrow material landward of the

[1] For the purpose of this consultation, we have rounded up the area dredged to 87 acres.

wall, and the beginning of dredging of the proposed berth and access channel. Construction of the sheet pile wall will include pile driving. Dredge material is anticipated to be sent to an existing offsite Confined Disposal Facility (CDF). Year 2 is proposed to include the continuance of dredging with a portion of the granular dredge material being placed onsite, landward of the sheet pile retaining wall and all other dredge materials being sent to an existing offsite CDF. Pile driving for the proposed wharf is anticipated to begin and possibly be completed during year 2. Year 3 construction will complete dredging of the berth and access channel and installation of the wharf piles. The in-water activities may include pile driving in addition to the operation of a dredge.

Table 1. In-water Construction Schedule

Year	Demolition of existing structures	Retaining wall/Sheet piles	Wharf/Pile driving	Berth and access channel/Dredging
1	x	x		x
2			x	x
3			x	x

3.3.1 Wharf Construction

3.3.1.1 Removal of Existing Docks

The initial phase of construction of the Edgemoor Container Port wharf will involve the removal of two existing wooden dock structures and remnant timber piles within the Construction and Dredging areas. Piles within the Dredging Area will be removed using vibratory methods. Piles outside of the Dredging Area will be cut off at the mudline. Some of the timber piles along the shore may be left in place.

3.3.1.2 Sheet Pile Retaining Wall Construction

A sheet pile retaining wall, consisting of PZ steel sheets, will be constructed along the landward edge of the wharf. The sheets will be interlocking to create a full coverage steel faced wall with a depth of 40.6 centimeters (cm) (16 inches (in)). The sheets will be installed by vibration in 3.0 to 4.6 m (10 to 15 ft) of water (post-dredging depths) and will be installed from the land side of the site from the existing grade, the majority of which is above the low tide line.

The deck will transition to land at the landward side of the wharf structure behind the sheet pile retaining wall/bulkhead. The sheet pile wall, which will also be coated for corrosion protection similar to the piles, will span an exposed height of approximately 7.6 m (25 ft). The retaining wall may include dead man anchors constructed in the landside fill or may be supported on the riverside by steel pipe piles, depending on the outcome of design analyses. The retaining wall will be integral with the wharf along the 792.5 m (2,600 ft) deck.

On the upriver side, the retaining wall transitions out of the subaqueous lands and terminates on the site. On the downriver end of the site, the sheet pile wall extends out of the subaqueous lands and continues to the property line to facilitate the site grading requirements.

An approximately 5.3-acre area of subtidal and intertidal waters between the sheet pile wall and the high tide line will be filled with suitable sediment or soil. The fill area will be separated hydraulically from the river by the sheet pile wall prior to the placement of fill to preclude impact to water quality or aquatic resources outside of the fill area.

3.1.3.3 Wharf Pile Installation

The wharf will be supported by a pile system consisting of approximately 4,500, 20-inch diameter, concrete-filled steel pipe piles. Plumb vertical piles will be spaced roughly on 3 m (10 ft) centers and batter (angled) piles will be placed in one row on 1.5 m (5 ft) centers for the wharf support. Two rows of piles intended to support gantry crane rails will be placed on 1.5 m (5 ft) centers beneath the wharf. Batter piles will be installed along the riverfront side of the wharf. The total number of piles to support the wharf also accounts for possible termination piles at the ends of the wharf. The piles will be coated with an epoxy coating for corrosion protection.

The piles will be installed from a barge using a combination of vibration and cushioned impact driving. A vibratory hammer will be used to drive the piles to refusal and then a cushioned impact hammer will be used to drive the piles to their final design depth. Cushion blocks will consist of multiple layers of plywood approximately 30.5 cm (12 in) thick. Piles will be driven in water 3.0-12.2 m (10 to 40 ft) deep (post-dredging depths). A reduced energy "soft-start" procedure, where the equipment will be operated at half-power for the first 15 minutes, will be used for both types of pile driving.

Pile installation for the Edgemoor Container Port Project is expected to take approximately 800 days to complete, with no in-water work between March 15 and July 15. Pile driving will be performed from two, possibly three, barges, each supported by one tug and one crew boat. The crew boat and tug might travel daily to and from the site and operate out of the existing Port of Wilmington, located approximately 4 km (2.5 miles) downriver of the Edgemoor site. Barges used for pile driving likely will stay on site for the duration of each pile-driving season.

3.4 Construction of Harbor/Dredging

The proposed action includes the deepening of an area of the Delaware River approximately 1,219.2 m (4,000 ft.) in length with a width extending from the boundary of the federal navigation channel to the landward side of the proposed wharf. This area encompasses approximately 139,354.56 square meters (1.5 million square feet) (approximately 87 acres).

3.4.1 Equipment used

Hydraulic dredging is proposed for the initial construction. Hydraulic dredging typically consists of a shallow draft ship (barge-like hull) that utilizes hydraulic pumps to suction a mix of sediments and water from the river bottom and pump the effluent through a discharge pipe up to several miles away. A suction intake contains a cutter head that rotates to disturb, or dig, the soil and sediment and mixes the cuttings with the suction water for removal. The soil-water slurry then travels through the pump and piping until it discharges to the storage location. The dredge discharge pipe is typically oriented to discharge into a CDF. The ship sweeps through the proposed dredge area, cutting away 0.6 to 0.9 m (2 to 3 ft) sections of material per pass. The slurry material generally contains 25 to 30 percent sediment and 70 to 75 percent water based on USACE Engineering Manuals. Neither mechanical dredging nor hopper dredging are proposed for this action.

3.4.2 Dredged Volume and Dredge Material Disposal

The initial dredging for the berth and primary harbor access is anticipated to require removal of approximately 3.3 million cy of river sediments and underlying soils. Project planning anticipates that this material will be placed in existing USACE CDFs along the Delaware River proximate to the Edgemoor Site and a portion (up to 500,000 cy) of dredged sediments may be placed on site for reuse as fill.

The Edgemoor expansion initial construction dredging is planned to occur over at least three dredge cycles, with the dredged materials going into existing CDFs located along the Delaware River. The primary disposal area proposed is Wilmington Harbor South CDF, but other existing CDFs may also be used, such as Wilmington Harbor North and Reedy Point North, and, as mentioned, a portion of the dredged sediments may be reused at the Edgemoor site as fill. Regardless of location, all dredged material not used as fill will be placed at permitted upland sites; therefore, the consequences of placement will not be considered further.

3.4.3 Dredging period and timing

Dredging for the Edgemoor Container Port Project is expected to take up to 3 years to complete, with no in-water work occurring between March 15 and July 15. Dredging will be performed with one cutterhead dredge over three dredge events, and will be supported by two tugs, a crew boat, and a hydrographic survey vessel. The initial event (Year 1), to occur over a period of 105 dredge days is proposed to occur between July and September. The second event (Year 2), to occur over a period of 60 dredge days is proposed to occur between January and February. The third event (Year 3), to occur over a period of 60 dredge days is proposed to occur between July and September. The crew boats, survey vessel, and some of the tugs are anticipated to operate out of the existing Port of Wilmington, located approximately 4 km (2.5 miles) downriver of the Edgemoor site, similar to the transfer of piles for wharf construction. The tugs, survey vessel and crew boats may travel back and forth to the Port of Wilmington each day while dredging is in progress.

Typically, dredging occurs over a 15 to 18-hour cycle per day, and the production rate is dependent upon parameters such as the type of dredge, pipeline length, dredging depth, and sedimentology of the material.

Table 2. Dredging Schedule

Dredging Event	Start Date	End Date	Dredging duration	Dredge quantity (in mcy)
Initial (Year 1)	July	September	105 days	1.3 – 1.6
Second (Year 2)	January	February	60 days	0.7 – 1.0
Third (Year 3)	July	September	60 days	0.4 – 0.8

3.5 Project Vessels and Project-Related Vessel Traffic

3.5.1 Vessels during construction

As discussed, dredging and wharf construction for the Edgemoor Container Port Project is expected to take up to 3 years to complete, with no in-water work between March 15 and July 15. During dredging, crew boats, the survey vessel, and some of the tugs are anticipated to operate out of the existing Port of Wilmington Autoberth, located along the right downriver side of the Federal Navigation Channel in the Delaware River, approximately 4.3 km (2.7 miles) downriver of the Edgemoor site.

All of the construction vessels will be shoal draft, with the tugs having the deepest draft at 4.6 m (15 ft) or less. Dredging will be performed with one cutterhead dredge supported by two tugs, a crew boat, and a hydrographic survey vessel. Pile driving for the wharf will be performed from two, possibly three, barges, each supported by one tug and one crew boat. All of the sheet pile installation for the bulkhead construction will be performed using land-based equipment. There will be some additional shoal draft vessel traffic during the initial deployment of the dredge slurry pipeline between the construction site and the CDF that will be used (Wilmington South or Wilmington North) during the initial dredge cycle. This vessel traffic will occur again at the conclusion of construction dredging when the slurry pipeline is disassembled and removed. During the initial year of construction, the USACE anticipates that construction will focus on installation of the sheet pile bulkhead and dredging within the footprint of the wharf.

Construction vessels traveling to and from the construction site will use the existing Federal Navigation Channel, with the exception of the vessels used to initially install the dredge slurry pipeline between the construction site and the CDF and during the disassembly and retrieval of the pipeline at the conclusion of construction dredging. These shoal draft construction vessels will operate along the right descending bank of the Delaware River.

The dredge will make the trip from the Autoberth to the construction site at Edgemoor once at the beginning of each of the three planned dredge events and will return to the Autoberth at the end of each dredge event. The tugs and crew boats may travel back and forth to the Port of Wilmington each day while dredging is in progress. The first dredge event is forecast to be the longest and last 3.5 months or 105 days, suggesting that the crew and tug boats would each make 210 trips during that event (daily delivery and retrieval of crew). Each of the subsequent two dredging events are anticipated to have shorter (2-month) durations yielding fewer crew and tug boat trips (60 days x 2 trips daily = 120 trips each for the crew and tug boat). To assess the dredging progress, the hydrographic survey vessel is anticipated to make the trip from the Autoberth to the dredge site once at the start of each dredge cycle and once at the conclusion of each dredge cycle for a total of 12 survey vessel trips. Therefore, four tug trips for two tugs, two from the Autoberth to the construction site and two return trips to the Autoberth, are anticipated per day in support of dredging.

Construction barges that will support pile driving for the wharf will be towed to the construction site once for each construction cycle by a tug. For the three barges anticipated, the tug will make three delivery trips from the Autoberth per day to the construction site and three return trips to the Autoberth. During the first year of construction, barge arrival at the site will be dependent on the progress of dredging. The entirety of wharf piles will be driven after the dredging of the area adjacent to the wharf (i.e., the berthing area), has been completed. The USACE anticipates that construction barges will remain in place at the site with periodic minor adjustments of location as pile driving progresses. The barges will be towed back to the Autoberth at the conclusion of each construction season, again requiring three tugboat trips to the construction site from the Autoberth and three return trips. A crew boat will carry the construction crew to and from the barges daily during weekdays. Pile driving is not anticipated to occur during weekends. During the 8-month (34 weeks, 5 days per week) construction season, the crew boat is anticipated to make approximately 170 trips to the construction site and 170 return trips for a total of 340 trips.

Table 3. Vessel Activity During Construction. Each vessel will have two trips, one from the Autoberth at the Port of Wilmington to the project site and one back to the Autoberth at the Port of Washington

Cycle	Activity	Vessel	Vessel #	Days	Trips per vessel	Total trips
1	Dredging	Crew	1	105	210	210
1	Dredging	Survey	1	2	4	4
1	Dredging	Tug	2	105	210	420
1	*All*	*All*				*634*
2	Dredging	Crew	1	60	120	120
2	Dredging	Survey	1	2	4	4
2	Dredging	Tug	2	60	120	240
2	Pile Driving	Crew	3	170	340	1020
2	Pile Driving	Tug	3	170	340	1020
2	*All*	*All*				*2,404*
3	Dredging	Crew	1	60	120	120
3	Dredging	Survey	1	2	4	4
3	Dredging	Tug	2	60	120	240
3	Pile Driving	Crew	3	170	340	1020
3	Pile Driving	Tug	3	170	340	1020
3	*All*	*All*				*2,404*
All	**All**	**All**				**5,442**

3.5.2 Vessels during port operation

The USACE Deep Draft Navigation Planning Center of Expertise (DDNPCX) performed an independent economic analysis and developed shipping projections for the Port with and without project conditions based on the recent shipping data for the Port of Wilmington (through 2020), and projections of regional economic and commodity growth. The economic analysis is performed with the USACE's HarborSim economic model with the input of DSPC and other stakeholders in the Port of Wilmington (e.g., the customers and operators), but is performed by the USACE DDNPCX in the Mobile District of USACE's South Atlantic Division.

The economic model considered a future without the project, which represents the projected container shipping traffic in the existing Port of Wilmington. After completion, DSPC anticipates that current container cargo operations at the Port of Wilmington will shift to the

Edgemoor facility (e.g., shipping traffic, container handling equipment, and operating systems). This portion of the existing baseline service represents approximately 30 percent of the annual ship calls. Bulk, break-bulk and roll-on/roll-off cargo operations will remain at the existing Port of Wilmington, as market forces do not favor significant increases in the throughput of these cargoes. Investments in the Port of Wilmington's landside container operations have resulted in a facility with the capacity of 675,000 TEU per year. In accordance with this modeling, the shipping traffic at the facility will be limited to containerized cargo, both standard and refrigerated, on container ships. No loose bulk, break bulk or liquid tankers will access the facility.

The economic analysis for the project considered the relocation of the landside container operations to the Edgemoor facility with the construction of berths maintained at a shipping depth of -13.7 m (-45 feet) MLLW. Based on a communication from USACE-SAD on July 30, 2021 (USACE, 2021), the projected annual container ship vessel calls, both with and without the project can be summarized as shown in Table 4.

Table 4. Projected annual vessel calls without the project and with the project at -13.7 m (-45 ft)

Economic Case	Vessel Calls 2027 (Year 1)	Vessel Calls 2047 (Year 20)
Without Project – Port at -11.6 m (-38 ft) MLLW	383	362
With Project - Port at -13.7 m (-45 ft) MLLW	324	299

The shipping traffic to the container terminal will vary from 3,000 TEU to 14,000 TEU vessels (Post Panamax Gen 3). The range of vessel sizes that will access the facility are shown in Table 5.

Table 5. Range of vessel sizes that will access the port

Vessel Class Name	Approximate TEU Capacity Range	Approximate Vessel Draft Range (Ft)	Approximate Vessel Length Range (Ft)
Sub-Panamax	0 – 2,000	<32	<700
Panamax	2,000 – 5,000	<44	820-970
Post Panamax Generation 1	4,000 – 7,000	44-47.5	284-1,050
Post Panamax Generation 2	7,000 – 10,000	44-47.5	263-1,150
Post Panamax Generation 3	10,000 – 14,000	44-50	380 – 1,250

The configuration of the container vessel fleet is rapidly changing as new, larger ships enter service because of the completion of the expansion of the Panama Canal in 2016, permitting the passage of larger vessels, and new environmental regulations (engine emission requirements) that limit the viability of older, smaller ships. The frequency of 10,000 TEU or larger ships calling on the east coast of the United States has increased from less than 3 percent in 2017 to 15 percent in 2020 and is projected to continue to rise. This growth in vessel size represents a larger percentage of the cargo throughput as each 10,000 TEU vessel moves twice the volume of the older Panamax ships. This continued transition of the fleet supports the projected reduction in ship call between Year 1 and Year 20 of the project (e.g., 21 to 25 fleet vessel calls per year in each economic condition).

DSPC has indicated that with additional landside construction, the annual throughput capacity of the facility would be increased beyond the capacity considered in the USACE DDNPCX analysis without additional berthing facilities. DSPC, in conjunction with the site operator, has indicated that additional capital investment in the landside container operations could increase the annual capacity of the facility to approximately 1,200,000 TEU, inclusive of existing import/export service, expanded import/export service and an allowance for operations and empty containers.

The expected increased cargo share per call can range from 2,000 TEU to 7,500 TEU, which would result in ship calls ranging from 160 to 480 calls per year to support the facility (if supported by only 12,000 TEU or 3,000 TEU vessel classes at full build out). Current projections, based on the project schedule, are that this vessel traffic will not occur until at least 2027, by which time the fleet will likely have further transitioned to the Post Panamax shipping class. In consideration of the potential for variability of the ship calls, which is based on the shipping fleet and economic conditions, this assessment has conservatively utilized 480 ship calls per year for the future case (considering the full land-side capital investment). This value is the highest number of potential vessel calls envisioned. Use of this number of vessels results in the potential for 118 new vessel calls (236 new vessel trips) if the capacity of the Edgemoor site is fully realized economically.

Container vessels calling at the new container port at Edgemoor would travel approximately 117 km (72.67 mi) from the mouth of Delaware Bay, a 3.1 km (1.94 mi) increase (1.4 percent increase in distance) in Delaware River travel over the current calls at the existing Port of Wilmington. Foreseeably, the container vessels would be met by two tugs in the Delaware River Federal Navigation Channel adjacent to the new Port and either assist berthing the container vessel or assist turning the container vessel 180 degrees before assisting with berthing the vessel. Following loading or unloading of the container vessel, tugs would assist departure maneuvers from the berth to the navigation channel. If the container vessel were not turned upon arrival, it would be turned with the assistance of tugs at the time of departure.

The tugs are anticipated to remain based in the Christina River. They are anticipated to travel the 3.1 km (1.94 mi) between the mouth of Christina River and the new Edgemoor port a maximum of four times per container ship call. A review of available information about the harbor tugs operating out of the Port of Wilmington (Wilmington Tug, Incorporated) in the Delaware River indicates that they are twin engine and twin propeller, shoal draft vessels with drafts typically under 4.6 m (15 ft).

The new (increased) 118 container vessel traffic annually calling at the Port of Wilmington Edgemoor Expansion would require an additional 472 tug trips (118 vessels x 2 = 236 new vessel trips; 2 tugs x 236 vessel trips = 472 tug trips). Those 472 tug trips would amount to an additional 1,474.2 km (916 mi) of tug travel per year. For comparison, the 118 new container vessels would yield 27,600 additional travel km (17,150 mi) per year in the Delaware River and Bay. For the purposes of this data, a vessel trip is defined as a container ship transiting from the Bay to the Port or a tug supporting a vessel movement portal to portal.

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.

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 Port 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 (0.4 in).

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 Plan

3.7.1 Dam No. 2 Rock Ramp Fishway

Brandywine Creek Dam 2 currently prohibits fish passage for both resident and migratory species including American shad, hickory shad, and river herring on the Brandywine Creek. Dam 2 is located at RKM 4.7 (RM 2.9) of the Brandywine Creek. A non-profit agency (Brandywine Shad 2020) commissioned a feasibility report to support passage or removal of a series of dams on the Brandywine Creek. Dam 1 was removed by the City of Wilmington in 2019, leaving Dam 2 as the downstream impediment to fish migration. Based on discussions between the City of Wilmington and DSPC, full removal of Dam 2 is not practical at this time as it provides the mechanism for the City of Wilmington to obtain supply for its potable water needs. Fish passage is to be provided to 12.5 acres of upstream habitat through the construction of a rock ramp fishway on the downstream face of the Dam 2. In essence, the rock ramp is intended to act in a natural manner to gradually elevate the streambed and water level to the height of the Dam 2 crest, thus allowing fish to swim over the dam. The structure and purpose of Dam 2 will be unchanged by the project so that the dam continues to serve the City of Wilmington water supply requirements.

Dam 2 is located above the fall line in Brandywine Creek and is approximately 7.6 km (4.7 mi) upstream of the Delaware River. As such, it is a shallow, non-tidal, fluvial body of fresh water. Water depths in the vicinity of Dam 2 range from a few inches to several feet. This portion of

Brandywine Creek has not been identified as habitat for endangered or threatened species and is not part of the designated Delaware River critical habitat for Atlantic sturgeon. Until 2019, sturgeon would not have had access to the compensation project site due to the presence of impassable Dam 1. Although there are no longer any physical barriers preventing access, ESA-listed species have not been reported in Brandywine Creek, and neither Atlantic nor shortnose sturgeon are likely to be present in this shallow, non-tidal, freshwater environment.

The rock ramp will consist of a series of step pools that raise the creek level below the dam to the height of the dam crest. The changes in elevation between each step pool will be approximately 0.3 m (1 foot). The openings to support fish passage between the steps are being designed in accord with guidance provided by US Fish and Wildlife Service (USFWS) fish passage criteria. The entire length of the proposed ramp is located upstream (above) the head of tide in Brandywine Creek within the City of Wilmington and above the former location of Dam 1.

The step pools will be created by depositing large pieces of virgin (first use) rip rap sized rock and clean natural boulders within the banks of Brandywine Creek downstream of Dam 2. The design specifications for the rock will take into consideration the hydraulic forces that may be encountered, shaping of the structure and necessary hydraulic conditions (depth and velocity) within each of the fish passage areas to promote fish use.

The step pools are to be constructed on the downside face of the dam and are proposed to consist of a combination of full width boulder row placed on the stream substrate where currently exposed rock and boulders provide riffle flow. In areas where the step pool would require boulder runs higher than 1.2 m (4 ft), additional rock is to be placed in the pool areas for structural stability. The conceptual plans are provided in the preliminary compensatory mitigation plan (Duffield 2021b). The boulders are to be placed with excavation equipment (i.e., tracked excavators) from the bank of the river. Temporary stone access pads within the stream will be utilized in areas with limited access to prevent equipment from operating within the normal stream flow. No significant stream diversion or bypass is proposed. Two gates, one on each side of the dam, are proposed to provide final passage. The gates, which will have the ability to be shut during low flow events to maintain the minimum pool elevation of the reservoir, will be required to be open during the migration season in spring/early summer as a condition of the final mitigation plan. The gates, which will each permit a flow of 25 cubic feet per second (cfs), represent approximately 4 percent of the average creek base flow and are designed to limit the hydraulic impact to the dam. A temporary dam will be installed in the reservoir to permit the installation of the gates, this structure will be in the portion of the creek that is not accessible to ESA species (e.g., on the upriver side of the dam).

No in-water work associated with this mitigation project will be permitted during the spring spawning and migration period for the target anadromous fish between March 15 and July 15, which also coincides with the work exclusion period established for ESA-listed species, if present.

3.7.2 Intertidal Habitat Creation with Wetland Enhancements

The Fox Point State Park is contiguous with, and immediately upriver of, the project site. The Park was created through filling activities performed along the Delaware River shoreline. Historical aerial photos for the site dating back to 1954 document the filling activities as well as the condition of the site prior to filling. The prior condition generally consisted of aquatic river habitat, and the placed fill material acted in the creation of the upland area that is the park today. The fill reportedly includes a variety of materials, principally dredged material from the Delaware River underlain by steel-making slag, bricks, timber, waste ingots, and ash furnace dust, in addition to miscellaneous trash and debris.

Along the upriver end of the park, a low-lying area overgrown with phragmites and having elevations ranging from approximately 1.8 to 2.4 m (6 to 8 ft) mean lower low water (MLLW) datum is separated from the Delaware River by a constructed revetment. The area has been identified as having potential for fill removal to restore the historic use of the site as intertidal habitat. The site, approximately 1.1 acre in size, is located near the upriver end of Fox Point Park along the Delaware River.

Existing invasive species of plants will be removed from the low-lying wetland creation area. The low-lying area will be excavated to elevations below mean high tide and planted with native wetland vegetation. High tide water depths within the wetland creation area are anticipated to range between 0.3 and 1.5 m (1 and 5 ft), which is suitable for suppressing phragmites. This work will be completed in existing upland areas, which are not subjected to tidal flow. Following the establishment of the grading within the wetlands, openings to support water exchange with Delaware River will be created by excavating through portions of the existing revetment. This will occur during low tide periods and will occur within the intertidal zone. The work will be performed with land-based equipment (e.g., tracked excavators) which will access the site from the existing revetment. Once the tidal flow is introduced to the habitat, plantings will be added by workers who will access the area during low tide on foot.

The in-water work associated with this mitigation project will include a time of year (TOY) restriction that prohibits in-water work between March 15 and July 15 to mitigate the impacts to ESA-listed species. The Delaware River adjacent to the proposed wetland creation area is designated as critical habitat for Atlantic sturgeon. A relatively small intertidal area adjacent to the revetment will be disturbed to create the hydraulic connection between the created wetland and the river. The wetland creation work is expected to occur in an existing upland area that currently is disconnected from the Delaware River. The excavation through the revetment near the end of the project will allow the wetland area to become part of Delaware River when finished.

3.8 Best Management Practices

The proposed action will employ practices that avoid or minimize potential adverse impacts to endangered species. For instance, the project was designed to avoid impacts to Cherry Island Flats by keeping all dredging to the downriver right side of the Federal Navigation Channel that extends along one side of Cherry Island Flats. To accomplish this goal, the wharf has been located as close to uplands as possible, given the closed waste deposits that are present within the upland portion of the project site. The wharf has been designed as a pile supported structure to promote water circulation and help maintain water quality.

During construction, the following measures will be implemented to avoid or minimize adverse impacts:

- In-water construction work such as dredging, pile driving, and construction vessel movements will not be performed during the spring sturgeon spawning season (March 15 to July 15).
- Construction vessels traveling to and from the construction site will use the existing Federal Navigational Channel, with the exception of the vessels used to initially install the dredge slurry pipeline between the construction site and the CDF and during the disassembly and retrieval of the pipeline at the conclusion of construction dredging. These shoal draft construction vessels will operate along the right descending bank of the Delaware River.
- Dredge monitoring will be employed to assess sediment and water quality during active dredging. Turbidity monitoring will be continuous. Sediment and water quality samples will be collected and analyzed periodically, in accordance with the federal and State of Delaware approved dredge monitoring plan.
- Dredging will be performed using hydraulic (cutterhead) dredging techniques. Mechanic (clamshell or bucket) dredging will not be used, as it is likely to generate more turbidity than hydraulic dredging methods and has a greater potential to impact, injure or kill sturgeon.
- The cutterhead dredge and suction pumps will not be started or operated until the cutterhead is in contact with river bottom sediments to reduce the potential for the cutterhead to injure sturgeon or suction entrap or entrain young sturgeon. The suction pump and cutterhead will be shutdown prior to lifting the cutterhead above the river bottom sediments.
- A vibratory hammer shall be used to initially install all piles until pile refusal is reached soft start with description.
- Cushion blocks will be used to reduce noise generated by impact pile driving after vibratory hammers are no longer effective.

Upland erosion and stormwater management during construction will employ best management practices. Stormwater quality will be monitored during construction in accordance with the approved dredge monitoring plan. Post construction stormwater monitoring will be in accordance with the polychlorinated biphenyl (PCB) minimization and monitoring plan approved by the Delaware River Basin Commission (DRBC). Land surface finishes within the landside portion of the project will conform to the State of Delaware approved Resource Conservation and Recovery Act (RCRA) Closure Permit and Post Closure Care Plan.

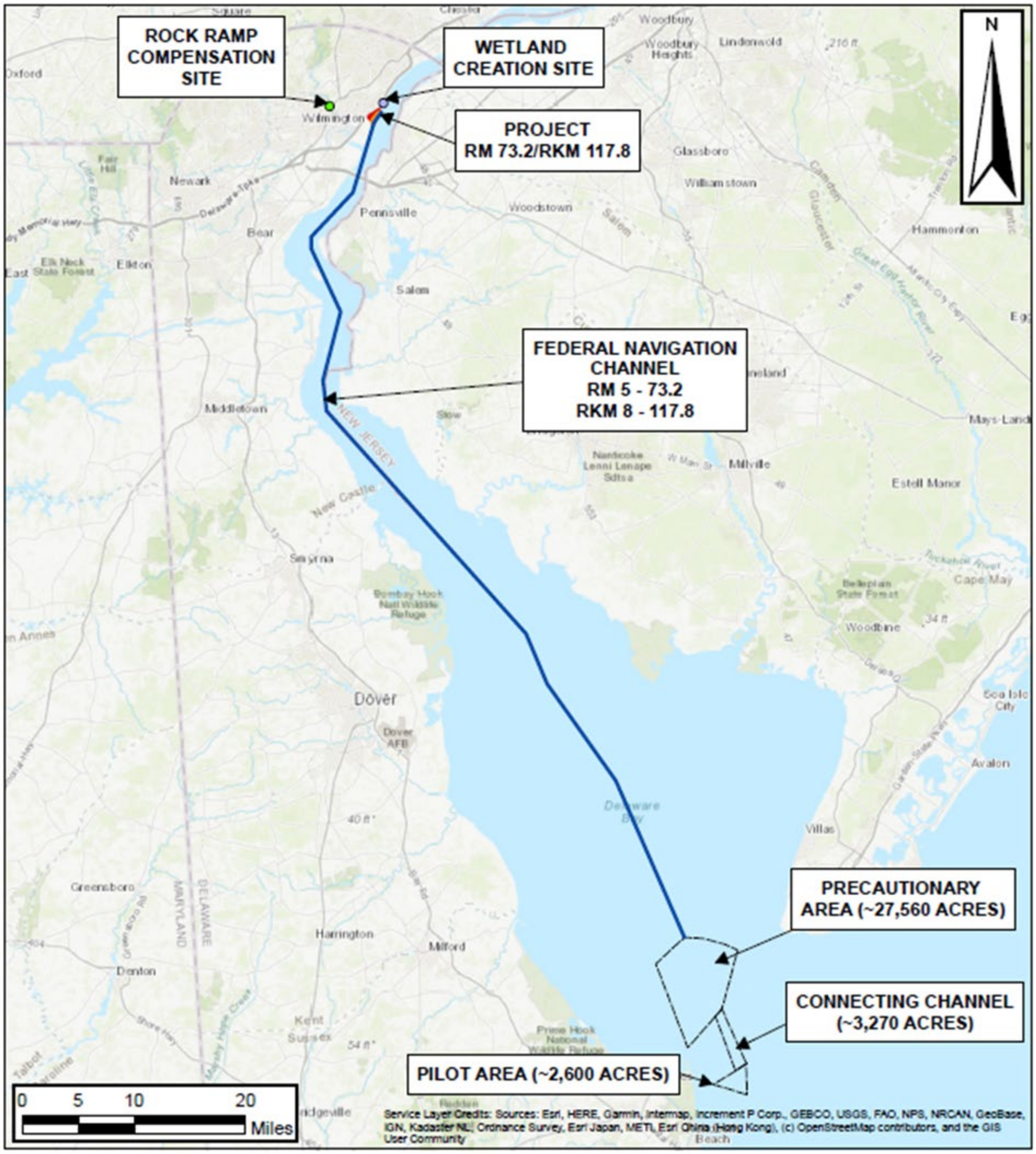
- In-water work at the Brandywine Creek Dam 2 fish passage site will not occur between March 15 and July 15 to avoid impacts to spawning migrations of anadromous fish.

- In-water work at the Fox Point State Park will not occur between March 15 and July 15 to avoid impacts to ESA species.
- Clean rock, relatively free of fine particles that might generate turbidity during placement at the Dam 2 construction site, will be used to construct the rock ramp.
- Excavation work at the wetland creation site within Fox Point Park and interior to the existing revetment will be completed under dry conditions before tidal flow is established between the wetland creation site and the Delaware River.
- Excavation through the revetment to allow tidal water exchange will only occur during low tide to minimize generation of turbidity in the Delaware River.

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 Port, and stressors associated with these activities. The components of the action area relative to the Port are: the area directly affected by construction of the wharf ("Construction Area") (5.5 acres) and dredging activities ("Dredging Area") (86.9 acres). In addition, the action area includes the areas that will be transited by cargo vessels calling at the Edgemoor facility when the Port is operating: the Delaware River Federal Navigation Channel from RKM 8-117.8 (RM 5 to 73.2) (~7,975 acres) (RKM/RM designations based on DRBC, 1969), the federal precautionary area between the mouth of Delaware Bay and the beginning of the federal channel (~27,560 acres), the pilot area just outside of the bay (~2,600 acres), and the channel connecting the pilot and precautionary areas (~3,270 acres). Container ships calling at Edgemoor are not expected to use anchorages and, after picking up a river pilot, will proceed directly up the navigation channel to an assigned berth. This action area also encompasses the area where vessels will travel between the Channel and the proposed Port during construction and operation. As the dredged material will be disposed of on land, no additional in-water areas will be affected by dredged material disposal. The action area also includes two locations where compensation projects will be constructed with in-water impacts, one located at approximately RKM 4.7 (RM 2.9) of the Brandywine Creek and the other located at the upriver end of Fox Point Park at RKM 119.7 (RM 74.4) of the Delaware River. The action area for the project is shown in Figure 1. The dredging area is shown on Sheet 2 of 18 and the Conceptual Site Plan for the Port illustrating the construction area is shown on Sheet 5 of 18 of the permit drawings, provided in Appendix 1 of the Biological Assessment.

Figure 1. Edgemoor Action Area



The action area also includes the area ensonified by underwater noise during pile driving. Based on the NOAA Fisheries GARFO Acoustic Tool, biologically significant sound levels could extend as far as 100 m (328 ft) from the pile being driven. In addition, the action area includes the area occupied by sediment plumes associated with dredging, which extend beyond the ensonified area. The sediment plume could extend up to 305 m (1,000 ft) from the cutterhead dredge. 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 occurs occupies approximately 935.5 acres (Figure 2).[2]

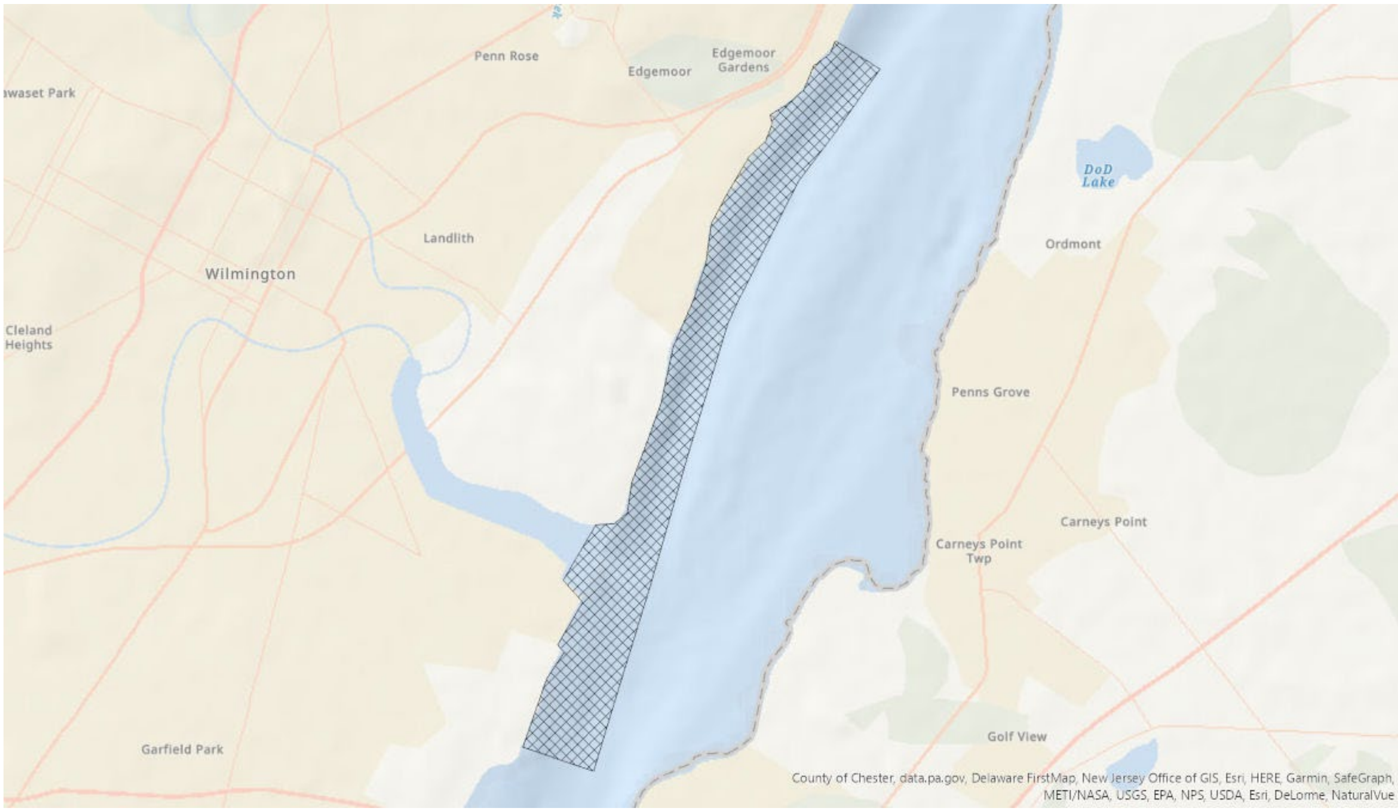


Figure 2. Map of action area where dredging (including sediment plumes), vessel traffic between the Federal Navigation Channel and the Port, and pile driving occurs

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.

The Project site lies between the Delaware shoreline and the Philadelphia to the Sea Federal Navigation Channel located approximately 150 m (492 ft) south of the shoreline and maintained at approximately -13.7 m (-45 ft) deep.

4.1.1 Construction Area

The construction area (5.5 acres) consists of the nearshore waterfront portion of the project where the proposed wharf will be constructed. Aquatic habitat in the construction area is

[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.

estuarine subtidal (0.35 acres) and intertidal (5.15 acres), with existing water depths ranging from approximately 0-1.5 m (0-5 ft). Bottom substrate consists primarily of sand and gravel, with some concrete rubble. The shoreline in the construction area experiences high energy from wind, tide, and shipping traffic, and is armored in many areas with rip-rap, gabion baskets, and pilings (Miller, 2020). There are no vegetated wetlands (Duffield Associates, Inc., 2018) or submerged aquatic vegetation (SAV) (Miller, 2020) within the construction area.

4.1.2 Dredging Area

The dredging area consists of 87 acres (including side slopes) of estuarine subtidal and intertidal habitat, with existing water depths ranging from approximately 0-13.7 m (0-45 ft) as illustrated on Sheet 4 of 18 of the permit drawings provided in Appendix 1 of the Biological Assessment. Bottom substrate within the dredging area consists of fine-grained sediments (silt/clay/sand), based on acoustic surveys conducted by Sommerfield and Madsen (2003) and the DNREC Delaware Bay Benthic Mapping Program (described by Wilson and Carter, 2008) (see Figs. 2-2 and 2-3), and field observations (Duffield Associates, Inc., "Geotechnical Report, Port of Wilmington, Edgemoor Expansion, Edgemoor, New Castle County, Delaware," dated October 2019, Miller, 2020). Shapefiles for the substrate mapping shown in Figures 2-2 and 2-3 were provided by the researchers who conducted the surveys (John Madsen, University of Delaware, pers. comm., May 15, 2019; Bart Wilson, U.S. Fish and Wildlife Service, pers. comm., April 3, 2019). Variations in the mapped substrates are noted between these surveys and other publicly available surveys. The published mapping, which is based on varied sampling techniques with variable accuracy, would be expected to result in slightly variable mapped results. The DNREC Delaware Bay 2019 survey data (for which the background documentation was not provided) was not considered since the information contained therein was not supported by the regional geology mapping or site-specific sampling (Duffield 2019). There are no vegetated wetlands (Duffield Associates, Inc., 2018) or SAV (Miller, 2020) within the dredging area. Salinity in this portion of the Delaware River ranges from freshwater in the spring to oligohaline during drier periods (typically in late summer-early fall). Mean tidal range in the Delaware River at Marcus Hook, PA, located approximately 10 km (6.2 mi) upriver of the Edgemoor site, is 1.70 meters (5.59 feet) (NOAA, 2019).

4.1.3 Federal Navigation Channel, Precautionary Area, and Pilot Area

The Federal Navigation Channel adjacent to and downriver of the Edgemoor site is maintained at a controlling depth of -13.7 m (-45 ft) MLLW. Substrate types within the channel vary widely from silty clay to gravel (Sommerfield and Madsen, 2003). The precautionary area and the pilot area consist of naturally deep areas at and near the mouth of Delaware Bay. Salinity ranges from tidal freshwater/oligohaline in the upper reaches of the federal channel to that of seawater at the mouth of Delaware Bay (Cronin *et al*., 1962; Polis and Kupferman, 1973).

4.1.4 Compensatory Mitigation Plan Areas

Through the permitting process, DSPC has prepared a State of Delaware Compensatory Mitigation Plan (Duffield, 2021b) and a federal Preliminary Compensatory Migration Plan (Duffield, 2021c). The purpose of the two mitigation plans is to offset the identified impacts to fish habitat from the project, which primarily result from the filling intertidal beach and shading associated with the proposed wharf. The compensatory mitigation plans include several upland

and in-water elements. The portions of the plan, which include alterations to aquatic environments, can be summarized as:

- The construction of a nature-like fishway on the face of Dam 2 on the Brandywine Creek in the City of Wilmington, Delaware. The dam is located at RKM 4.7 (RM 2.9), which is located above the fall line (i.e., above the head of tide). Following the removal of Dam 1 in 2019, the dam currently represents the downstream impendent to anadromous fish passage. The existing substrate of the creek is a combination of rocky and sandy substrate in both riffle and pool areas varying in elevation from 5.8 to 6.7 m (19 to 22 ft) (Duffield 2021c); and
- The construction of intertidal habitat at Fox Point State Park at RKM 119.7 (RM 74.4) of the Delaware River to create a functioning intertidal habitat and wetlands. To restore tidal flow, fills that have been placed will be removed. The project will include removal of a portion of a revetment placed to construct the current shoreline and removal of material, believed to be primarily slag and dredge tailings, to restore the natural river substrate (Duffield 2021b).

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 6). We present the rationale for this "not likely to adversely affect" determination below. No take is anticipated or exempted.

Table 6. NLAA listed species present within the Action Area and 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, Massachusetts. 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 percent 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).

5.1.1.1 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, is 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.

5.1.1.2 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 operation of the Port. 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).

5.1.1.2.1 Dredging Entrapment
Hydraulic cutterhead dredges will be used 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. For this action, the cutterhead is hydraulic. The cutterhead dredge operates with the dredge head buried in the sediment; however, a flow field is produced by suction as it operates. 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.

5.1.1.2.2 Underwater Noise

For construction of the proposed Port, vibratory and impact hammers will be used to drive roughly 4,500 20-inch steel pipe piles and approximately 792.5 m (2,600 ft) of sheet pile. 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[3]. Based on the calculations, the peak (i.e., approximately 10 m (32.8 ft) from the source) sound pressure level (SPL_{peak}) associated with cushioned impact pile driving to install steel piles is 197 dB re 1 μPa. The estimated root mean square sound pressure level (SPL_{RMS}) at the same distance is 176 dB re 1 μPa and SEL was measured to 165 dB re 1 μPa. Based on this, we expect

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

that turtles within 13.3 m (44 ft) from the piles will react to the sound by avoiding the area. We do not expect exposure to noise from driving the 24-inch sheet piles with a vibratory hammer.

Table 7. 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})
20" Steel Pipe	Cushioned Impact	197	176	165
20" Steel Pipe	Vibratory	198	177	166
24" AZ Steel Sheet	Vibratory	175	160	160

Table 8. 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}
20" Steel Pipe	Cushioned Impact	NA	NA	NA	NA	13.3
20" Steel Pipe	Vibratory	NA	NA	NA	NA	NA
24" AZ Steel Sheet	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 13.3 m (44 ft) of pile driving (Table 8). It is expected that underwater noise levels will be below 175 dB RMS at distances beyond 13.3 m (44 ft) 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 to be meaningfully measured or detected. Therefore, the effects of noise on sea turtles are insignificant.

5.1.1.2.3 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 at 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 1.8 m (6 ft) 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 300-500 m (984.3 to 1,640.4 ft) 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 (ERC 2016, Nightingale and Simenstad 2001).

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 91 m (300 ft) 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 (Barton *et al.* 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 suspended sediments in 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. 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.

5.1.1.2.4 Habitat Modification

Dredging and pile driving 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. The two mitigation projects (construction of a rock ramp fishway at Dam No. 2 on the Brandywine Creek and intertidal habitat creation/wetland enhancements at Fox Point State Park) are not expected to impact sea turtles. Sea turtles are pelagic marine animals and are not likely present in Brandywine Creek, which is above the head of tide, and the construction at Fox Point will be land-based. As such, construction at the mitigation sites is not anticipated to expose sea turtles to any habitat disturbance.

Benthic substrate in the action area is largely composed of sand and silt 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 may affect 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. Because the action area is a small fraction of the Bay and Estuary, 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 3.3 million cy of material will be dredged for construction of the proposed Port. The area to be affected by dredging activities 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, we do not expect that these reductions in forage will have impacts on the fitness of any sea turtles. The river is approximately 2.4 km (1.5 mi) wide and behavioral modification from exposure to pile driving noise is expected to only occur within 13.3 m (44 ft) 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. Given the small portion that will be affected of the total habitat available for foraging sea turtles, any consequences to foraging from periodic dredging and pile driving are too small to be meaningfully measured or detected, and are insignificant.

5.1.1.2.5 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 (Associates 2014). 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 will add five vessels to the action area. Dredging operations also 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, 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.

5.1.2.1 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 on 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.

5.1.2.2 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 off shore of the mouth of the Delaware Bay. As such, this section will only address the effects of vessel traffic to whales.

5.1.2.2.1 Vessel Traffic

Once operational, we anticipate that the proposed Port will receive up to 118 new 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 *et al.* 2021). However, right whale sightings have been documented near the mouth of the Delaware Bay and on 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 Port 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 cargo 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 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. Barkaszi *et al.* (2021) 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 percent. At speeds below 11.8 knots, the probability of a vessel decreases to less than 50 percent, and at 10 knots or less, the probability is further reduced to approximately 30 percent. Most ship strikes have occurred at vessel speeds of 13-15 knots or greater (Barkaszi *et al.* 2021, Jensen and Silber 2003). 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. The timing of the SMA coincides with the seasonal migrations of right whales, which is when they are mostly likely to be in mid-Atlantic waters. Vessels 19.8 m (65 ft) or longer are required to operate at speeds of 10 knots or less when traveling through the SMA. Vessels anticipated with future Port 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 Port 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 460 m (500 yards) of the vessel. Thus, measures to avoid vessel strike are already in place and will be applicable to the vessels associated with the Port. 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 cargo vessels 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, cargo 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. While there are no physical barriers 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, vessels that will travel at a speed of 10 knots or lower between November 1 and April 30, the likely absence of whales in the area between May 1 and October 31, and requiring vessels to keep a 460 m (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.

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 (Shortnose Sturgeon Status Review Team) 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 (Shortnose Sturgeon Status Review Team) 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 below while details on activities that impact individual shortnose sturgeon in the action area can be found in sections 6, 7, and 8.

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 9 below.

Table 9. General life history for 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 (Hilton *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 (Hilton *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 (Hilton *et al.* 2016). Males spawn for the first time approximately 1-2 years after maturity with spawning typically occurring every 1-2 years (Hilton *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 (Brundage 2018, Hilton *et al.* 2016). Shortnose sturgeon spawn in freshwater reaches of their natal rivers when water temperatures reach 9–15°C (48.2–59°F) in the spring (Hilton *et al.* 2016). Spawning occurs over gravel, rubble, and/or cobble substrate (Hilton *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 (4-89 ft) (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 (0 – 93.2°F) (Dadswell *et al.* 1984, Heidt and Gilbert 1978); with temperatures above 28°C (84.2°F) considered to be stressful. Depths used are highly variable, ranging from shallow mudflats while foraging to deep channels up to 30 m (98.4 ft) (Dadswell *et al.* 1984, Kynard 2016). Salinity tolerance increases with age. Young-of-the-year must remain in freshwater; however, adults have been documented in the ocean with salinities of up 30 parts-per-thousand (ppt) (Hilton *et al.* 2016). Dissolved oxygen (DO) 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 (Hilton *et al.* 2016).

Shortnose sturgeon feed on benthic insects, crustaceans, mollusks, and polychaetes (Hilton *et al.* 2016). Both juvenile and adult shortnose sturgeon primarily forage over sandy-mud bottoms, which support benthic invertebrates (Carlson and Simpson 1987, Hilton *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 (Hilton *et al.* 2016).

In northern rivers, shortnose aggregate during the winter months in discrete, deep (3-10m (9.8-32.8ft) freshwater areas with minimal movement and foraging (Brundage 2018, Buckley and Kynard 1985, Dadswell 1979, Dovel *et al.* 1992, Hilton *et al.* 2016). In the winter, adults in southern rivers spend much of their time in the slower moving waters downstream near the salt-wedge and forage widely throughout the estuary (Collins and Smith 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).

5.2.1.2 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 the 1880s (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.

5.2.1.3 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 (Shortnose Sturgeon Status Review Team) 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).

5.2.1.4 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 (248.5 mi). 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 (Shortnose Sturgeon Status Review Team) 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[4]. The other two groups (Connecticut/Housatonic and the Hudson River) function as independent populations.

While there is migration within each metapopulation (i.e., between rivers in the Gulf of Maine and between rivers in the Southeast) and occasional migration between populations (e.g., Connecticut and Hudson), interbreeding between river populations is limited to very few individuals per generation; this results in morphological and genetic variation between most river populations (Grunwald *et al.* 2008, King *et al.* 2001, SSSRT (Shortnose Sturgeon Status Review Team) 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.

[4] 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.

5.2.1.5 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 also 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 (>19.7 in) 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.* (2017a) 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 Kennebec 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.* (2017b) 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 (RM 72); Piotrowski 2002); currently shortnose sturgeon cannot move past the Essex Dam in Lawrence, MA (RKM 46 (RM28.6)). 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 Connecticut River was recaptured in the Housatonic River (T. Savoy, CT DEP, pers. comm.). Three individuals tagged in the Hudson River were captured in the Connecticut River, 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 indicate an extensive increase in abundance from the late 1970s (13,844 adults (Dovel *et al.* 1992), to the late 1990s (56,708 adults (95% CI 50,862 to 64,072; Bain *et al.* 1998). This increase is thought to be the result of high recruitment (31,000 – 52,000 yearlings) from 1986-1992 (Woodland and Secor 2007). Woodland and Secor (2007) examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

Delaware River-Chesapeake Bay Metapopulation

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

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 (Shortnose Sturgeon Status Review Team) 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 from 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.

5.2.1.6 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 Connecticut). 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 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 young-of-the-year and juveniles as compared to adults (Gross *et al.* 2002); that is, increasing the number of young-of-the-year 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 of this Opinion. More information on threats experienced in the action area is presented in the *Environmental Baseline* (section 6) of this Opinion.

5.2.1.7 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 conditions for foraging, resting and spawning. In many rivers, particularly in the Southeast, habitat is compromised and continues to impact the ability of sturgeon populations to recover. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. The loss of any population or metapopulation would result in the loss of biodiversity and would create (or widen) a gap in the species' range.

5.2.1.8 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 life history traits and 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, long residence time in rivers from egg to adulthood, the sensitivity of adults to very specific spawning cues that can result in years with no recruitment if conditions are not met, and the impact of losses of young of the year and juvenile cohorts prior to reaching spawning age on 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 are likely to occur in the action area and provide information on the use of the action area by Atlantic sturgeon.

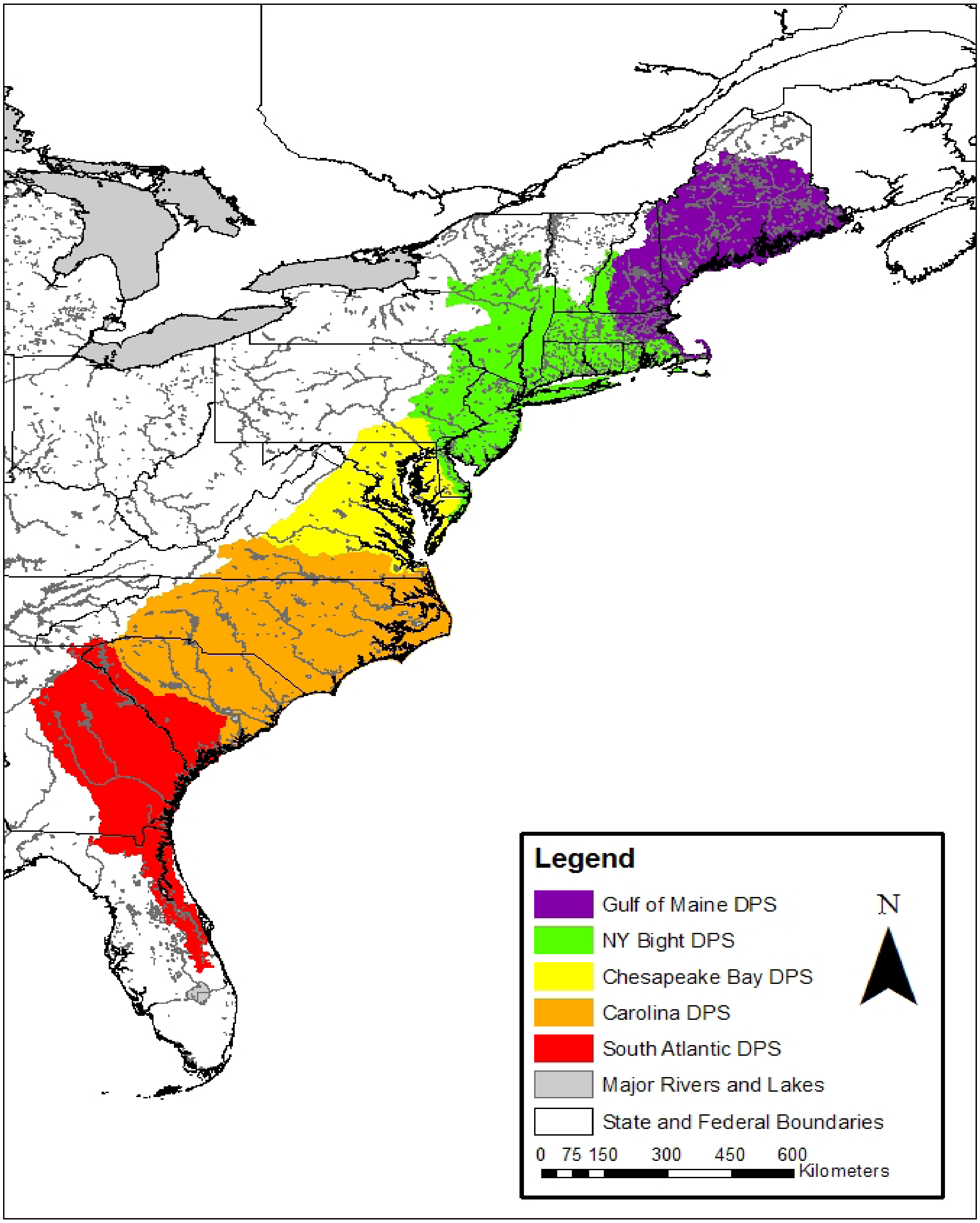
The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is one of two subspecies of *A. oxyrinchus*, the other being the Gulf sturgeon, *A. o. desotoi*. It is distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA

(77 FR 5880; February 6, 2012). 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 3). 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 (Kazyak *et al.* 2021, Wirgin *et al.* 2015a). 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 3. Map depicting the five Atlantic sturgeon DPSs to show the general northern and southern boundaries of each DPS at the coastline. The extent to which each DPS is depicted inland is for general illustration purposes only, since the regulatory definitions of each DPS do not include a western boundary.



5.2.2.1 Life History, Habitat Use, and Abundance

The Atlantic sturgeon is a long-lived (approximately 60 years), late maturing, and estuarine dependent, anadromous[5] fish (ASSRT 2007). They are a relatively large fish, even amongst sturgeon species (Pikitch *et al.* 2005). Once mature, they continue to grow, and the largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.3 m (14 ft) (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 like 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 10 below. Depending on life stage, sturgeon may be present in freshwater, marine and estuarine ecosystems.

Table 10. 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 the 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

[5] 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 (NMFS 2017b, ASSRT 2007) at sites with flowing water and hard bottom substrate (Bain *et al.* 2000, Balazik *et al.* 2012a, 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 m (88.6 ft) (Bain *et al.* 2000, Crance 1987, Leland 1968, Scott and Crossman 1973). This is also supported by tagging records, which show that Atlantic sturgeon return to their natal rivers to spawn (ASSRT 2007). 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 by females range from 400,000 to approximately 4 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 correlates with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006).

Water temperature appears to play the 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), and remain on the spawning grounds throughout the spawning season (Bain 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren 1983, Smith 1985), make rapid spawning migrations upstream, and quickly depart following spawning (Bain 1997). Females may leave the estuary and travel to other coastal estuaries until outmigration to marine waters in the fall (NMFS 2017b, Bain 1997, Bain *et al.* 2000, Balazik *et al.* 2012a, Breece *et al.* 2013, Dovel and Berggren 1983, Greene *et al.* 2009, Hatin *et al.* 2002, 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.* 2012c, Breece *et al.* 2013, Dovel and Berggren 1983, Greene *et al.* 2009, Hatin *et al.* 2002, Ingram *et al.* 2019, Smith 1985, Smith *et al.* 1982)

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). Incubation time for the eggs increases as water temperature decreases (Mohler 2003). At temperatures of 20° and 18° C (68° and 64.4°F), 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 (1.2 in); 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 exhausts the yolk sac and becomes (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-the-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[6] (ASSRT 2007, Dadswell 2006, Dovel and Berggren 1983, Hilton *et al.* 2016). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other benthic invertebrates (ASSRT 2007, Bigelow and Schroeder 1953, 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 1983, 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 m (164 ft.) deep, only returning far upstream to the spawning areas when they are ready to spawn (Bain 1997, Breece *et al.* 2016, Dunton *et al.* 2012, ASSRT 2007, 2015, Savoy and Pacileo 2003). Diets of adult and migrant subadult Atlantic sturgeon include gastropods, annelids (Polychaetes and

[6] Some of the published literature for Atlantic sturgeon uses the term juvenile to refer to all sexually immature Atlantic sturgeon, including sexually immature fish that have emigrated from the natal river estuary. We use "juvenile" in reference to immature fish that have not emigrated from the natal river estuary, and we use the term "subadult" for immature Atlantic sturgeon that have emigrated from the natal river estuary.

Oligochaetes), crustaceans, and fish such as sand lance (ASSRT 2007, Bigelow and Schroeder 1953, Guilbard *et al.* 2007, Savoy 2007).

Marine and Coastal Distribution

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. 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*. 2015a; Wirgin *et al*. 2015b; Wirgin *et al*. 2018). A comprehensive analysis of Atlantic sturgeon stock composition coast wide provides further evidence that natal origin influences the distribution of Atlantic sturgeon in the marine environment. Atlantic sturgeon that originate from each of the five DPSs and from the Canadian rivers were represented in the 1,704 samples analyzed for the study. However, there were statistically significant differences in the spatial distribution of each DPS, and individuals were most likely to be assigned to a DPS in the same general region where they were collected (Kazyak *et al*. 2021). For the New York Bight DPS, the results support the findings of previous genetic analyses that Atlantic sturgeon belonging to the DPS occur in the Gulf of Maine and in the South Atlantic Bight but that they are most prevalent in the Mid-Atlantic Bight. (ASMFC 2017b, 2019, ASSRT 2007, Chambers *et al.* 2012, Dadswell 2006, Dovel and Berggren 1983, 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).

Based on fishery-independent, fishery dependent, tracking, and tagging data, Atlantic sturgeon appear to primarily occur inshore of the 50 m (164 ft) 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, Wirgin *et al.* 2015a). However, they are not restricted to these depths and excursions into deeper (e.g., 75 m (246 ft)) 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.* 2004a, 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 2012b). 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 (66 ft), 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 m (66 ft) (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 m (82 ft) (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.* 2004a, Waldman *et al.* 2013, Wippelhauser 2012a, 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).

5.2.2.2 Abundance

Atlantic sturgeon ocean abundance (see Kocik *et al*. 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (Table 11). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean; however, it is not a comprehensive stock assessment. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the USFWS sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The USFWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag, release, and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery vessels.

Table 11. Description of the ASPI model and NEAMAP survey based area estimate method.

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

In addition to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) trawl surveys (Kocik *et al.* 2013).[7] NEAMAP trawl

[7] 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.

surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall since 2007 and spring since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

As illustrated by Table 12 below, the ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey. As noted above, the ASPI model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the USFWS sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The NEAMAP estimate, in contrast, is more empirically derived and does not depend on as many assumptions. For the purposes of this Opinion, while the ASPI model is considered as part of the 2017 ASMFC stock assessment, we consider the NEAMAP estimate as the best available information on population size.

Table 12. Model results

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

Available data do not support estimation of true catchability (i.e., net efficiency X availability) of the NEAMAP trawl survey for Atlantic sturgeon. Thus, the NEAMAP swept area biomass estimates were produced and presented in Kocik *et al.* (2013) for catchabilities from five to 100 percent. In estimating the efficiency of the sampling net, we consider the likelihood that an Atlantic sturgeon in the survey area is likely to be captured by the trawl. Assuming the NEAMAP surveys have been 100 percent efficient would require the unlikely assumption that the survey gear captures all Atlantic sturgeon within the path of the trawl and all sturgeon are within the sampling area of the NEAMAP survey. Thus, we have in previous biological opinions (e.g., NMFS 2014) and will, for this Opinion, rely 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

2013). 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 are 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 13). 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 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 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 of the NEAMAP trawls, and therefore a portion of the Atlantic sturgeon's range.

Table 13. Calculated population estimates based on 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 (2017a) 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 2017b).

The genetic diversity of Atlantic sturgeon throughout its range has been well-documented (Bowen and Avise 1990, ASSRT 2007, 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 by using genetic data from individual fish. 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.

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-the-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 New York Bight 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 New York Bight 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 13 percent; New York Bight 42 percent; Chesapeake Bay 24 percent; South Atlantic 20 percent; and Carolina 1 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 1 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 Section 7 consultation purposes, 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).

Depending on life stage, sturgeon may be present in freshwater, marine and estuarine ecosystems. The action area for this biological opinion ranges from freshwater in the spring to oligohaline during drier periods (typically in late summer-early fall); therefore, this section will focus only on the distribution of Atlantic sturgeon life stages (juvenile, subadult and adult) tolerant of these conditions; it will not discuss the distribution of Atlantic sturgeon life stages (eggs, larvae, juvenile, subadult, adult) in exclusively freshwater ecosystems, but will discuss their movements into/out of natal river systems. For information on Atlantic sturgeon distribution in freshwater ecosystems, refer to: (ASSRT 2007); 77 FR 5880 (February 6, 2012); 77 FR 5914 (February 6, 2012); (NMFS 2017b); and (ASMFC 2017b).

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 2017b, 2019, Dadswell 2006, Dovel and Berggren 1983, Dunton *et al.* 2012, Dunton *et al.* 2015, Dunton *et al.* 2010, Erickson *et al.* 2011, Kynard *et al.* 2000, Laney *et al.* 2007, ASSRT 2007, O'Leary *et al.* 2014, Stein *et al.* 2004b, Waldman *et al.* 2013, Wirgin *et al.* 2015a, Wirgin *et al.* 2012).

Based on fishery-independent, fishery dependent, tracking, and tagging data, Atlantic sturgeon appear to primarily occur inshore of the 50 m (164 ft) 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, Wirgin *et al.* 2015a, 2015b). However, they are not restricted to these depths and excursions into deeper (e.g., 75 m (246 ft)) 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.* 2004a, 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 2012a). 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 (66 ft), 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 m (66 ft) (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 m (82 ft) (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 2012a, Wippelhauser *et al.* 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.* 2004a).

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), and remain on the spawning grounds throughout the spawning season (Bain 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren 1983, Smith 1985), make rapid spawning migrations upstream, and quickly depart following spawning (Bain 1997). 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 1983, Greene *et al.* 2009, Hatin *et al.* 2002, NMFS 2017b, 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 1983, Greene *et al.* 2009, Hatin *et al.* 2002, Ingram *et al.* 2019, Smith 1985, Smith *et al.* 1982).

5.2.2.3 Stock Assessments

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 specifically occupied areas designated as critical habitat for Atlantic sturgeon (NMFS 2017d, NMFS (National Marine Fisheries Service) 2017). 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 called for a coastwide moratorium on fishing for Atlantic sturgeon in state waters to allow 20 consecutive cohorts of females to reach sexual maturity and spawn, which will facilitate restoration of the age structure. The moratorium was expected to be in place for 20-40 years 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.* 2016b).

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 2017b). The assessment concluded all five DPSs of Atlantic sturgeon, as well as each individual DPS remain depleted relative to historic abundance (Table 13). 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 2017b). In summary, across all five DPSs, several life history traits and factors contribute to making Atlantic sturgeon particularly sensitive to existing and future threats. These factors include the small size of many river-specific populations, existing gaps in the range, late maturation, long residence time in rivers from egg to juvenile, the sensitivity of adults to very specific temperature spawning cues which can result in years with no recruitment if conditions are not met, and the impact of losses of young of the year and juvenile cohorts prior to reaching spawning age on population persistence and stability.

In 2022, pursuant to Section 4(c)(2)(A) of the ESA, we published the 5-year reviews for the New York Bight DPS, Chesapeake Bay DPS, and Gulf of Maine DPS of Atlantic sturgeon. As part of the 5-year reviews, we are required to consider new information that has become available since the New York Bight DPS of Atlantic sturgeon was listed as endangered in February 2012. In addition to previously available information, this Opinion includes new information that has become available since the ESA-listing and critical habitat designation for the New York Bight DPS, and is considered the best available scientific information. The findings of the 5-year reviews are included in our discussion below for each DPS. The complete 5-year reviews for the three DPSs, are available on our website at: https://www.fisheries.noaa.gov/action/5-year-review-new-york-bight-chesapeake-bay-and-gulf-maine-distinct-population-segments.

5.2.2.4 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.

5.2.2.5 Recovery Goals

Recovery Plans for the Gulf of Maine, New York Bight, and Chesapeake Bay DPSs are currently at the draft stage, but have not been prepared for the South Atlantic and Carolina 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.

5.2.2.6 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 Cocheco and Salmon Falls) Rivers. Spawning has been documented in the Kennebec River, and recent information from (Wippelhauser *et al.* 2017) confirms the location of occurrence (between RKM 70 and 75 (RM 43.5 and 46.6)). During this study, between 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 ongoing to determine whether Atlantic sturgeon are spawning in the other rivers within the DPS, but as of now, nothing is confirmed.

Bigelow and Schroeder (2002 (revised)) 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 (Atlantic States Marine Fisheries Commission) 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, Maine (ASMFC 2007, NMFS (National Marine Fisheries Service) and U.S. FWS (U.S. Fish and Wildlife Service) 1998); and (4) as mentioned above, the capture of three Atlantic sturgeon larvae between RKM 72 and RKM 75 (RM 44.7 and RM 46.6) 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. Additionally, limited new information regarding spawning periodicity indicates that over a four-year period from 2010-2014, one fish was detected in three consecutive years on the Kennebec River spawning grounds. The majority of fish (12 out of 21) were only detected during one season (Wippelhauser *et al.* 2017). The data confirms variability in spawning periodicity.

Atlantic sturgeons that spawn elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT 2007). Additionally, Atlantic sturgeon that spawn in the Gulf of Maine DPS have been detected off of Delaware (Wirgin *et al.* 2015a; Kazyak *et al*. 2021) and as far south as Cape Hatteras. 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). The Saco River supports a large aggregation of Atlantic sturgeon that forage on sand lance in Saco Bay and within the first few kilometers of the Saco River, primarily from May through October. 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 (RM 6.2) 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).

Data collected from 11 dead adult Atlantic sturgeon in the Bay of Fundy (seven individuals with age ranges from 17 to 28 years) further informs the DPS mixing that occurs throughout the marine range and in Canadian waters (Stewart et al. 2017). Dadswell *et al*. (2016) describes seasonal aggregations and movement (generally May through September) of Gulf of Maine DPS sturgeon in the Bay of Fundy. This information supports the 2012 listing rule's finding that 35 percent of Atlantic sturgeon captured in Canadian fisheries are of Gulf of Maine DPS origin (Wirgin et al. 2012).

Multiple threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers *et al.* 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.* 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon bycatch has been prohibited since 1998.

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). Incidentally caught Atlantic sturgeon in state-managed fisheries are reported to the ASMFC through voluntary reporting (ASMFC 2019), and in federally managed fisheries through the Northeast Fishery Management plans. 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), as stated above. Thus, a significant number of the Gulf of Maine 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 (18 to 105 in), but the majority (72.5 percent) were less than 150 cm (59 in) 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).

Habitat disturbance and direct mortality from anthropogenic sources are significant concerns to Atlantic sturgeon. 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. However, studies by Reine *et al.* (2014) and Balazik *et al.* (2020) indicate that sturgeon are not attracted to dredge activity and that dredging (i.e., associated noise and turbidity) was not a barrier to passage, even though fish can become impinged or entrained in the dredging gear, itself.

Connectivity is disrupted by the presence of dams on some rivers in the Gulf of Maine region, including the Merrimack River. While there are also dams on the Kennebec and Androscoggin 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.* 2017a). 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.* 2017a). 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[8], 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 similar results which were an effective population size of: 63.4 (95% CI=47.3-91.1) (ASMFC 2017b) 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 occurs in Kennebec and may occur Androscoggin and 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 2017b). 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 with some overwintering as well (Hylton *et al.* 2018, Little 2013). However, none of the new information indicates recolonization of the Saco River for spawning.

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 because 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

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[8] 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.

(ASMFC 2007). Atlantic sturgeon from the Gulf of Maine DPS are not commonly taken as bycatch in areas south of Chatham, Massachusetts, and tagging results 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). Dadswell *et al.* (2016) describes characteristics of the seasonal aggregation of sturgeon in the Bay of Fundy and 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.

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

5.2.2.7 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, Massachusetts 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 *et al.* 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). However, in 2014 new inconclusive information regarding potential Connecticut River spawning was received. Additionally, 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).

There is uncertainty related to trends in abundance for the New York Bight DPS (ASMFC 2017b). 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 2017b). 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 the abundance of the New York Bight DPS or otherwise quantify the trend in abundance because of the limited available information.

At this time, there are no overall abundance estimates for the entire New York Bight DPS. There are, however, some abundance estimates for specific life stages (e.g., natal juvenile abundance, spawning run abundance, and effective population size). In 1995, sampling crews on the Hudson River estimated that there were 9,500 juvenile Atlantic sturgeon in the estuary. Because 4,900 of these were stocked hatchery-raised fish, about 4,600 fish were of wild origin. Based on the juvenile assessments from Bain *et al.* (2000), the Hudson River suffered a series of recruitment failures, which triggered the ASMFC fishing moratorium in 1998 to allow the populations to recover. Based on commercial fishery landings from the mid-1980s to the mid-1990s, the total abundance of adult Hudson River Atlantic sturgeon was estimated to be 870 individuals (Kahnle *et al.* 2007). Using side scan sonar technology in conjunction with detections of previously tagged Atlantic sturgeon, Kazyak *et al*. (2021) estimated the 2014 Hudson River spawning run size to be 466 sturgeon (95% CI = 310-745). While the spawning run estimate by Kazyak et al. (2021) cannot be directly compared with the estimated total abundance of adults in the early 1990s to determine if adult abundance has changed since the fishery was closed, it is clear that adult abundance is still several magnitudes lower than historical abundances. There is evidence to support the notion that the Hudson River spawning population is more robust than the Delaware River spawning population. This is further supported by the fact that Atlantic sturgeon originating from the Hudson River spawning population are more prevalent in mixed aggregations than sturgeon originating from the Delaware River spawning population.

At the time of listing, catch-per-unit-effort (CPUE) data suggested that recruitment remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980s (ASMFC 2010, Sweka *et al*. 2007). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s while the CPUE is generally higher in the 2000s as compared to the 1990s. Given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. However, the New York State Department of Environmental Conservation (DEC) has conducted annual surveys for Atlantic sturgeon juveniles in the Hudson River since 2004. Recent analyses suggest that the catch rate of juvenile Atlantic sturgeon belonging to the Hudson River spawning population has increased, with double the average catch rate for the period from 2012-2019 compared to the previous eight years, from 2004-2011 (Pendleton and Adams 2021). Thus, the fishing moratorium may have resulted in an increase in recruitment of female spawners (and consequently number of juveniles produced) or the increase may have been because survival of early life stages and/or juveniles has increased (for unknown reasons) in the Hudson River since 2004.

White *et al.* (2022) recently estimated the number of adults (Ns) 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.* 2022), 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 Ns 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.* (2022) concluded that bias in the data when sample size of offspring is small may result in the Ns being underestimated, as such, the Ns for Delaware River Atlantic sturgeon is likely between 125 and 250. Hale *et al.* (2016) estimated that 3,656 (95% CI = 1,935-33,041) early juveniles (age zero to one) utilized the Delaware River estuary as a nursery in 2014.

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 population of reproductive individuals needed for a particular Ne 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 the 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% CI=171.7-230.7; (O'Leary *et al.* 2014)) and 156 (95% CI=138.3-176.1), respectively, (Waldman *et al.* 2019), while estimates for the Delaware River spawning population from the same studies are 108.7 (95% CI=74.7-186.1) (O'Leary *et al.* 2014) and 40 (95% CI=34.7-46.2) (Waldman *et al.* 2019), respectively. Genetic testing can differentiate between individuals originating from the Hudson or Delaware River and available information suggests that the straying rate is moderate between these rivers (Grunwald *et al.* 2008). However, the small sample size and the potential inclusion of non-natal fish in the samples may bias the calculations for the Delaware and Hudson Rivers (L. Lankshear, personal communication, April 2023).

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, although the White *et al.* (2021) study did not address the status of short and long term viability of either population. This trend 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 (Wirgin *et al.* , 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 New York Bight 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.

New information from Breece *et al*. (2021) supports evidence of males having shorter spawning periodicity than females, but that females have more variability in the timing and number of spawning runs they make in the Hudson River. Salvage data from 2016 of a female Atlantic sturgeon in the Delaware River provided further support for the timing of spring spawning. Although the most recent Stock Assessment noted that movement of tagged fish and anecdotal reports suggest a fall spawning in the Delaware River; no further information is available to confirm whether it is occurring at this time.

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 (9 to 25 in) 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: (1) it is the closest of the known spawning rivers to the Connecticut; the most robust of all of the spawning populations; and, (2) it 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. Based on the genetic analysis of the captured juveniles using the calculations utilized for the Hudson and Delaware Rivers, the effective population (Ne) size for the Connecticut River was estimated to be 2.4 sturgeon (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.

As previously mentioned, there is no abundance estimate for the New York Bight DPS. As such, for the 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 use the mixed stock marine analysis as a proxy for in river composition because we do not have a subadult and adult mixed stock analysis for in-river usage. Therefore, we define the subadult and adult abundance of the New York Bight DPS as 34,567 sturgeon (NMFS 2014). 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.* 2012c, 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.

A number of threats to Atlantic sturgeon exist in marine waters including bycatch in fishing gear. Atlantic sturgeon bycatch in fisheries authorized under Northeast FMPs is estimated to be four percent of adults. As presented in the mixed stock analysis results by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid-Atlantic Bight region were sturgeon from the New York Bight DPS. 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. Commercial shad fishery continues in the Delaware Bay but is closed in the Delaware River. In the Hudson River, sources of potential mortality include vessel strikes and entrainment in dredges. Impingement at water intakes, including the Danskammer, Roseton, Indian Point, Salem, and Hope Creek (on the Delaware river) 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 additional 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, and climate change (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 contaminant exposure. Annual differences in the capture rates of age 0-1 Atlantic sturgeon in the fall and comparisons to annual dissolved oxygen levels during the preceding summer months provide additional evidence that low dissolved oxygen levels are causing or contributing to the death of the young sturgeon in the Delaware River in some years (Moberg and DeLucia 2016; Stetzar *et al*. 2015; Park 2020). On December 1, 2022, the EPA issued a determination that revised Water Quality Standards are necessary for the Delaware River Estuary to meet the requirements of the Clean Water Act. Specifically, the EPA determined that the aquatic life designated uses and corresponding dissolved oxygen criterion in Zones 3, 4, and RKM 126.8 to 112.7 (RM 78.8 to 70.0) of Zone 5 of the Delaware River Estuary must be revised to protect the propagation of resident and migratory fish species, including Atlantic and shortnose sturgeon, which are likely experiencing adverse effects under the currently applicable Water Quality Standards that were established in 1967.

On the Delaware River, a dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron 2009), and the river receives significant shipping traffic. A dredged navigation channel is present in the Hudson River as well. Although dredging occurs regularly, some projects have observers and some do not. At this time, 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. 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, and individuals using the aforementioned habitat for specific behaviors. 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.

Vessel strikes have been identified as a major threat in the Hudson and Delaware Rivers for migrating sturgeon and individuals aggregating on limited spawning or overwintering grounds. Vessel strikes occur in the Delaware River and Bay. One-hundred and three (103) Atlantic sturgeon mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2005 to 2019, and at least 65 of these fish were large adults and subadults (data provided by DNREC, 2020). 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, 108 Atlantic sturgeon carcasses were observed on the Hudson River and reported to the NYSDEC between 2013 and 2017. Of these, 71 were suspected of having been killed by vessel strike (NMFS 2017b). 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.

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, 2019, Waldman *et al.* 2013, Wirgin *et al.* 2015b, 2018). These findings support the conclusion of Wirgin *et al.* (2015a) 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 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 one 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[9] 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 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

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, White *et al*. (2021) found that their genetic analysis could not distinguish Delaware River Atlantic sturgeon from Hudson River Atlantic sturgeon as clearly as they could distinguish Atlantic sturgeon from other rivers included in the study. This more recent study

[9] 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.

reinforces the findings of Grunwald (2008) that there is moderate straying between river systems, which further supports the single DPS represented in the New York Bight.

There is uncertainty related to trends in abundance for the New York Bight DPS (ASMFC 2017b). The 2017 ASMFC Atlantic Sturgeon Stock Assessment states that the 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. However, new information suggests that these conclusions primarily reflect the status and trend of only the Hudson River spawning population (NMFS 2022). Some of the impacts 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 and would potentially restrict habitat for other necessary behaviors. With already limited tidal freshwater habitat available for spawning, habitat could be further reduced and the occurrence of low dissolved oxygen within early juvenile rearing habitat could increase. As evidenced by the studies of Hare *et al.* (2016b) 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.* 2004b). For Atlantic sturgeon, the model-based estimates of annual bycatch in gillnet and bottom trawl gear published in ASMFC (2017) represent the best available information for and analysis of bycatch. From 2011-2015, the average annual bycatch of Atlantic sturgeon in bottom otter trawl gear was 777.4 sturgeon under the best fit model. From 2011-2015, the average annual bycatch of Atlantic sturgeon in gillnet gear was 627.6 sturgeon under best fit model (ASMFC 2017b).

The best performing model for each gear type was applied to Vessel Trip Reports (VTRs) to predict Atlantic sturgeon bycatch across all trips. The total bycatch of Atlantic sturgeon from bottom otter trawls ranged between 624-1,518 fish over the 2000-2015 time series. The proportion of the encountered Atlantic sturgeon recorded as dead ranged from 0-18 percent (average 4 percent). This resulted in annual dead discards ranging from 0-209 fish. The total bycatch of Atlantic sturgeon from gillnets ranged from 253-2,715 fish. The proportion of Atlantic sturgeon recorded as dead ranged from 12-51 percent (average 30 percent), resulting in annual dead discards ranging from 110-690 fish. Otter trawls and gillnets caught similar sizes of Atlantic sturgeon, with most fish in the 3.3-6.6 ft (100-200 cm) total length range, although both larger and smaller individuals were captured. Wirgin and King (2011), indicates that 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 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). With improved water quality and toxic discharges limited through regulations, reduced in-water pollutants may be less of a concern, but legacy pollutants may exist long term in the benthic environment. When pollutants are present on spawning and nursery grounds, where sensitive life stages occur, there is potential for long-term impacts to developing individuals.

Vessel strikes occur in the Delaware River and Bay, and many mortalities have been identified as large adults and subadults. The New York DEC has also reported that dead Atlantic sturgeon with vessel strike injuries in the river in 2019, confirming that vessel strikes are also an issue on the Hudson River. 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, and are assumed to be of New York Bight DPS origin.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (ASMFC 2007, Boreman 1997, Brown *et al.* 2012, Kahnle *et al.* 2007). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. For the listing of the New York Bight DPS, we determined that the 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 (77 FR 5880, February 6, 2012). We reviewed new information for the 5-Year Review that became available since the listing and we concluded that the status of the DPS has likely neither improved nor declined from what it was when the DPS was listed in 2012. We, therefore, continued to recommend classification for the New York Bight DPS of Atlantic sturgeon as "endangered." (NOAA 2022).

5.2.2.8 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay 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 Chesapeake Bay DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. Recent data confirms that Chesapeake Bay Atlantic sturgeon are most prevalent in the marine environment throughout the Mid-Atlantic Bight from Delaware to Cape Hatteras (Kazyak *et al.* 2021). The riverine range of the Chesapeake Bay DPS and the adjacent portion of the marine range are shown in Figure 3. 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.* 2017, 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 2017b, Hilton *et al.* 2016, Kahn 2019). However, information for these populations is limited and the research is ongoing.

Age to maturity for Chesapeake Bay DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 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). Recent data indicates that Chesapeake Bay DPS juvenile Atlantic sturgeon remain in the natal estuary between one and four years before emigrating to the marine environment (Balazik *et al*. 2012b), and that males mature at about age 10 and females at age 15 (Balazik *et al.* 2012b; Hilton *et al*. 2016). New information regarding spawning periodicity is supported by the fact that acoustically-tagged males have made annual returns to spawning locations. Tagged females have returned approximately every two to three years, with some returning annually (Balazik *et al*. 2017a; Kahn *et al*. 2019; Kahn *et al*. 2021; Secor *et al*. 2021). Additionally, Kahn *et al*. (2021) used detections of tagged male and female sturgeon to inform the sex ratio in the Pamunkey River spawning population (males make up approximately 51 percent (95% CI=0.43-0.58 of the adult population).

There is currently no total abundance estimate for the Chesapeake Bay DPS; however, we estimated subadult and adult abundance in marine waters and concluded that approximately 8,811 sturgeon comprise the DPS (NMFS 2013). There are also 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 2019); 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.* 2017). 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 2017b).

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, 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.

New information regarding the importance of temperature on spawning and movement of sturgeon indicates that a relatively narrow temperature range (20°C to 25°C (68°F to 77°F)) triggers spawning, (Balazik *et al*. 2012a; Balazik *et al*. 2020; Hager *et al*. 2020; Secor *et al*. 2021), and new research has also demonstrated that limited hard-bottom habitat for Atlantic sturgeon spawning activities exist in Chesapeake Bay tributaries (Austin 2012; Bruce *et al*. 2016; Secor *et al*. 2021). Further informing potential spawning locations is research regarding the upriver range of the species based on detections of tagged adult Atlantic sturgeon (Balazik *et al*. 2021a; Hager *et al*. 2014; NMFS 2017; Secor *et al*. 2021), which supports the notion that available, suitable spawning habitat is sparse.

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

Decreased water quality also threatens Atlantic sturgeon of the Chesapeake Bay DPS, especially since the Chesapeake Bay system is vulnerable to the 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, EPA 2008, ASSRT 2007, 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 some areas of the Bay's health, the ecosystem remains in poor condition. In 2022, 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). The score remained unchanged from 2020; however, of the 13 indicators assessed, three improved, three declined, and seven stayed the same. While 32 percent is one percent lower than the state of the Bay score in 2018, this was an 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 unchanged score is largely a result of failures to make needed changes on farmland to reduce pollution, but noted improvements due to the promising results from oyster reef restoration, regulations allowing the striped bass population to rebuild by 2029, less phosphorous in the water and a smaller dead zone. Highlights from the 2022 report are summarized below:

- Monitoring data indicated that the 2022 dead zone was the tenth smallest in the past 38 years;
- Water clarity dropped one point in the report due to average water clarity in the Bay decreasing slightly in 2022 compared to 2020;
- In the pollution category nitrogen, toxics, and dissolved oxygen indicators were unchanged, the phosphorus indicator improved, and overall water clarity declined. Recent farm conservation funding at the federal and state levels should help reduce nitrogen and phosphorus pollution, which fuels harmful algal blooms that remove dissolved oxygen from the water;
- In the fisheries category, the rockfish (striped bass) and oyster indicators rose, while the blue crab indicator declined(Chesapeake Bay Foundation 2020); and
- In the habitat category, scores for underwater grasses, forest buffers, and wetlands remained unchanged, but resource lands fell slightly by a point. Resource lands refer to forests, natural open areas, and well-managed farmland. The drop in score was largely due to approximately 95,000 acres of farms and forests transitioning to development across the Bay watershed during the most recent reporting period, from 2013/14 to 2017/18.

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 2017b, Balazik *et al.* 2012c, Fox *et al.* 2020). There has been an increased number of vessel struck sturgeon reported in the James River in recent years (ASMFC 2017b). However, it is unknown to what extent the numbers reflect increased carcass reporting.

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

Summary of the Chesapeake Bay DPS

There are no overall abundance estimates for the entire Chesapeake Bay DPS or for the spawning populations in the James River or the Nanticoke River system; however, estimates from the marine environment and effective population size are available. A study on effective population size for Atlantic sturgeon that are spawned in the James River examined the effective population size of both the spring and fall spawning populations, whereas in other rivers, only the fall pawning run was considered.

At this time, spawning for the Chesapeake Bay DPS is known to occur in only the James and Pamunkey Rivers and in the Nanticoke River system. Spawning may be occurring in other rivers, such as the Mattaponi, 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). 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, 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).

Some of the impacts from the threats that facilitated the decline of the Chesapeake Bay DPS have been removed (e.g., directed fishing) or reduced because 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 Chesapeake Bay DPS of Atlantic sturgeon. Of the 35 percent of Atlantic sturgeon incidentally caught in the Bay of Fundy, about one percent were Chesapeake Bay DPS fish (Wirgin *et al.* 2012). Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (ASMFC 2007, Boreman 1997, Kahnle *et al.* 2007). The Chesapeake Bay DPS is currently at risk of extinction given (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect the potential for population recovery.

5.2.2.9 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 3. Sturgeon are commonly captured 64.4 km (40 mi) 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 m (164 ft) deep (ASMFC 2007, Stein *et al.* 2004a), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms.

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. We determined spawning was occurring if young-of-the-year were observed or mature adults were present in freshwater portions of a system (Table 14). 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 14. Major rivers, tributaries, and sounds within the ranges of the Carolina DPS and currently available data on the presence of 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 *et al.* 2002). Secor *et al.* (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.

Although 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.

5.2.2.10 South Atlantic DPS of Atlantic sturgeon

The South Atlantic DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto Rivers (ACE) Basin southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida. The marine range of Atlantic sturgeon from the South Atlantic DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the South Atlantic DPS and the adjacent portion of the marine range are shown in Figure 3.

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, and Satilla Rivers. We determined spawning was occurring if young-of-the-year were observed, or mature adults were present, in freshwater portions of a system (Table 15). 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. Mary's 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. Mary's 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 South Atlantic DPS likely use other river systems than those listed here for their specific life functions.

Table 15. Major river, tributaries, and sounds within the range of the South Atlantic DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

River/Estuary	Spawning Population	Data
ACE (Ashepoo, Combahee, and Edisto Rivers) Basin, SC; St. Helena Sound	Yes	1,331 YOY (1994-2001); gravid female and running ripe male in the Edisto (1997); 39 spawning adults (1998)
Broad-Coosawhatchie Rivers, SC; Port Royal Sound	Unknown	
Savannah River, SC/GA	Yes	22 YOY (1999-2006); running ripe male (1997)
Ogeechee River, GA	Yes	age-1 captures, but high inter-annual variability (1991-1998); 17 YOY (2003); 9 YOY (2004)
Altamaha River, GA	Yes	74 captured/308 estimated spawning adults (2004); 139 captured/378 estimated spawning adults (2005)
Satilla River, GA	Yes	4 YOY and spawning adults (1995-1996)
St. Marys River, GA/FL	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 South Atlantic DPSs, it is likely that some of the historical 8,000 fish would be attributed to both the Carolina DPS and South Atlantic 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 South Atlantic 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 South Atlantic 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 South Atlantic 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 lifespan also allows multiple opportunities to contribute to future generations, this is hampered within the South Atlantic DPS by habitat alteration, bycatch, and from the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch.

Dredging is contributing to the status of the South Atlantic DPS by modifying spawning, nursery, and foraging habitat. Habitat modifications through reductions in water quality and dissolved oxygen are also contributing to the status of the South Atlantic 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 South Atlantic 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 South Atlantic DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch 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 South Atlantic 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 (87 RMs) 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 (15 RMs) 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 (153 RMs) 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 (85.1 RMs) to where the main stem river discharges at its mouth into Delaware Bay. In total, these designations encompass approximately 547 km (340 mi) 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) 2017). That document provides background information on the current status and function of the four critical habitat units designated for the New York Bight DPS, and summarizes their ability to support reproduction, survival, and juvenile development, and recruitment. Additional information on the status of the New York Bight DPS relevant to the current status and function of critical habitat can be found in section 5.2.2.7.

> 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 1983, 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 (RM 16). 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 (RM 56).
>
> In August 2006, an adult-sized Atlantic sturgeon was observed as far upriver as the Holyoke Dam spillway lift at approximately RKM 143 (RM 89) (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)[10].
>
> The Hudson River is one of the most studied areas for Atlantic sturgeon. The upstream

[10] 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.

limit for Atlantic sturgeon on the Hudson River is the Federal Dam at the fall line in Troy, NY, approximately RKM 246 (RM 153) {ASSRT, 1998 #78;Dovel, 1983 #2956;Hilton, 2016 #596}. 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 1983, Hilton *et al.* 2016, Kahnle *et al.* 1998, Van Eenennaam *et al.* 1996). The area around Hyde Park (approximately RKM 134 (RM 83)) is considered a likely spawning area based on scientific studies and historical records of the Hudson River sturgeon fishery (Bain *et al.* 2000, Dovel and Berggren 1983, 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 m (40 to 79 ft) (Bain *et al.* 2000). Similar conditions occur at RKM 112 (RM 70), an area of freshwater and water depths of 21 to 27 m (69 to 88.5 ft)(Bain *et al.* 2000).

Catches of Atlantic sturgeon less than 63 cm (25 inches) fork length suggest that sexually immature fish utilize the Hudson River estuary from the Tappan Zee (RKM 40/RM 25) through Kingston (RKM 148/RM 92) (Bain *et al.* 2000, Dovel and Berggren 1983, Hilton *et al.* 2016). Seasonal movements of the immature fish are apparent as they primarily occupy waters from RKM 60 (RM 37) to RKM 107 (RM 66.5) during summer months and then move downstream as water temperatures decline in the fall, primarily occupying waters from RKM 19 (RM 12) to RKM 74 (RM 46) (Bain *et al.* 2000, Dovel and Berggren 1983, Haley 1999). In a separate study, Atlantic sturgeon ranging in size from 32 to 101 cm (12.6 to 40 inches) 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 (137 RMs) (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, Pennsylvania 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/RM 83) and the mouth of the Schuylkill River (RKM 148/RM 92) (Sommerfield and Madsen 2003). Based on tagging and tracking studies, Simpson (2008) suggested that spawning habitat exists from Tinicum Island (RKM 136/RM 84.5) to the fall line in Trenton, NJ (RKM 211/RM 131). 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 (59 inch) 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, New Jersey (RKM 201/RM 125), and inhabited areas of the river ± 30 RKM (±19 RM) from the estimated salt front for 84 percent of the time with smaller peaks occurring 60 to 100 RKM (37.3 to 62.1 RM) 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 a 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 (12 RM) within a 24-hour 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 m (18 ft) deep from the river mouth to RKM 8 (RM 5), and then approximately 2 m (6.6 ft) 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 upper portion of the action area for the proposed work considered in this biological opinion covers the Delaware River critical habitat unit from RKM 118 (RM 73.3) 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 Port access channel, turning basin, and wharf, indirect effects from turbidity only extends as far as 500 m (1,640 ft) from a cutterhead dredge. The river is approximately 2.4 km (1.5 mi) wide at the Port site. It also includes the Philadelphia to the Sea Federal Navigation Channel, RKM 8-133 (RM 5-133). 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, New Jersey to Wilmington, Delaware. However, larger stretches of the New Jersey shoreline below Little Tinicum Island (RKM 138 (RM 86)) 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/RM 58) 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 approximately 23 km (14.3 mi) downstream from the Port. 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/RM 65) is less developed with large stretches of undeveloped shoreline. The Supawna Meadows National Wildlife Refuge is located approximately 22 km (13.7 mi) downstream of the proposed Port 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, Delaware (approximately RKM 104/RM 64.6).

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, New Jersey, 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 intent of the Trenton Flow Objective is 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. At any given time, the salinity levels reflect the opposing influences of freshwater inflow from the 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 (RM 27) is considered polyhaline (18-30ppt) with a transition zone between RKM 44-50 (RM 27-31), RKM 50-92 (RM 31-57) is mesohaline (5-18ppt) with a transition zone between RKM 92-94 (RM 57-58), RKM 94-121 (RM 58-75) is oligohaline (0.5-5ppt), and upstream of RKM 121 (RM 75) is considered fresh (0.0-0.5ppt).

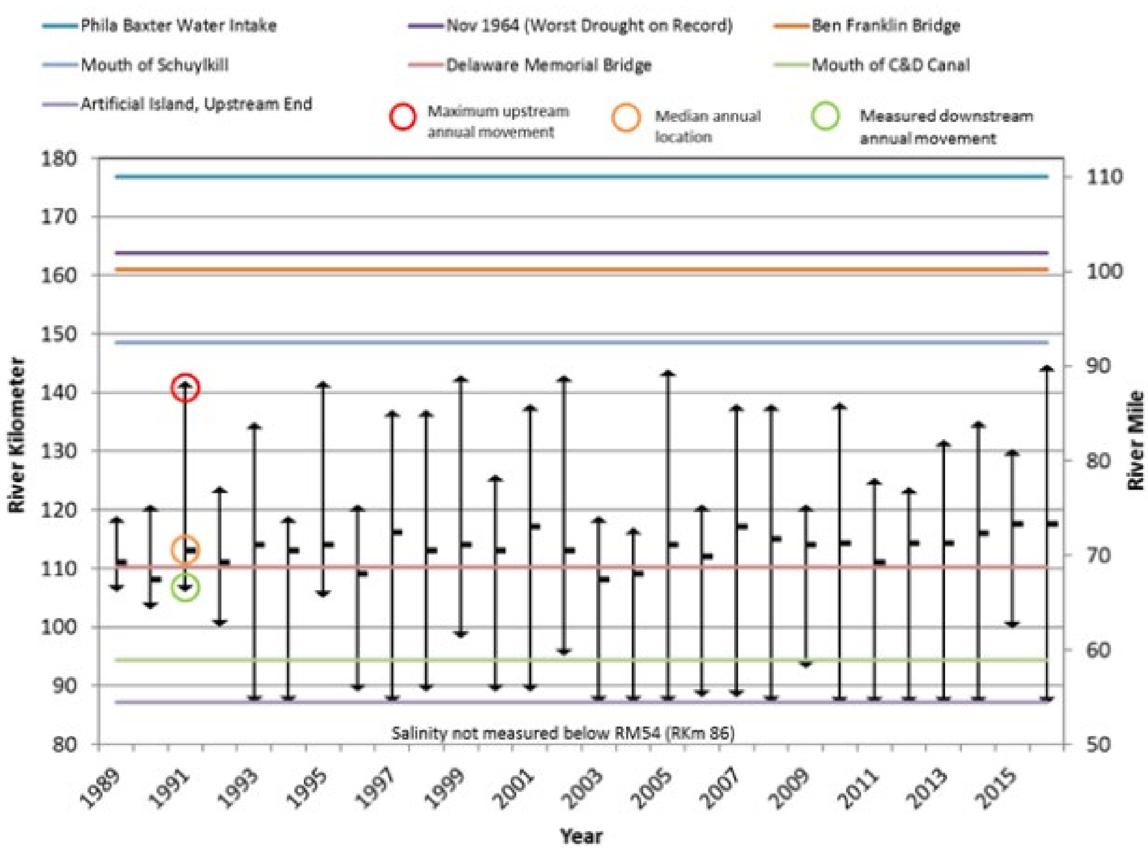
The salt front is considered the freshwater-saltwater interface in the estuary and the location is derived by calculating where the seven-day average chloride concentration equals 250 ppm (parts per million) in the River. Its location fluctuates in response to changing freshwater inflows and with each tidal cycle, but calculations show that current median salt front location range from RKM 107.8 and 122.3 (RM 67 and 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 RKM 122 (RM 76) (September) and RKM 108 (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 84.9 cubic meters per second (3,000 cubic feet per second) in the Delaware River at the Trenton, New Jersey gage. Therefore, since 1970, low-flow values that once occurred 10 percent of the time now occur only 1 percent 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 RKM 112.7/RM 70) 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 RKM 120.50/ RM 75 with the downstream limit of larvae rearing fluctuating between RKM 104/RM 65 and RKM 129/RM 80. It appears likely that Atlantic sturgeon larvae in the Delaware River drift for only a short period of time, since long duration drift from the presumed spawning areas would transport the larvae into waters of higher salinity, where they would not survive. As with the larvae of other sturgeon species, Atlantic sturgeon have likely evolved river/population specific patterns of dispersal that result in their movement downriver from spawning areas to optimal rearing areas upriver of the salt front (Hilton *et al*., 2016). The presumed Atlantic sturgeon spawning reach in the lower tidal Delaware River (RKM 125-137/RM 77.7-85.1) overlaps with the area of greatest abundance of young-of-the-year Atlantic sturgeon (RKM 123-129/RM 76.4-80.2), which suggests that post yolk-sac larvae dispersal is minimal. Thus, although the action area does not support sturgeon spawning, larval rearing may occur within the action area in years when the salt front is closer to the downstream end of the median salt front range. However, older life stages of Atlantic sturgeon are more 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 (18.6 mi) of the salt front (2013), which is inclusive of the upper reach of the action area.

Figure 4. Range of annual salt front locations from 1989-2016. The salt front river mile 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.

The U.S. Geological Survey (USGS) continuously measures DO at the Chester, Pennsylvania gage in the Delaware River (USGS 01477050). Dissolved oxygen in the Delaware River near the proposed Port vary greatly based on seasonality, with mean monthly average DO ranging between 12.23 to 10.87 mg/L in the winter months (i.e., December through January) to between 6.87 and 5.67 mg/L in the summer months (i.e., June through August) (see Table 16). 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 percent of observations near the Reedy Island gage in the lower Delaware River met daily mean water quality standards criteria and 98.7 percent of observations in the lower Delaware River and Delaware Bay met the instantaneous minimum criteria.

Table 16. Mean monthly dissolved oxygen in the Delaware River at Chester, PA (USGS 01477050) from January 2009 to December 2019

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mean monthly dissolved oxygen (mg/L)	12.23	-*	12.28	9.75	7.90	6.87	6.13	5.67	6.36	7.31	8.81	10.87

* No dissolved oxygen data was available at this location for the month of February

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 (Niklitschek and Secor, 2009; Niklitschek and Secor, 2010). In the Atlantic sturgeon critical habitat designation, 6.0 mg/l DO or greater was selected as the level of dissolved oxygen sturgeon would need to prevent avoiding an area (82 FR 39160, August 17, 2017). There are no reported DO sensitivities for adult shortnose sturgeon, the life stage most likely to be present within the action area, but adults are typically more tolerant of low DO levels. 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 (72.5°F) experienced a significant decrease in percent survival between 3.5 and 3.0 mg/l DO; however, this experiment was conducted in lab and fish in the wild are more likely to attempt avoid areas with low DO before the effects are lethal. Therefore, in an estuary with fluctuating DO levels, if the fish are able to avoid the area then the first, most likely effect, is loss of the use of that habitat because the fish are avoiding it. 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 percent (LC50) of 77 to 104 day old fish to be 2.7 mg/l (32% DO saturation, 22°C (71.6°F), 4‰), 2.2 mg/l (28% DO saturation, 26°C (78.8°F), 4.5‰), and 3.1 mg/l (42% DO saturation, 30°C (86°F), 2‰). Annual differences in the capture rates of age 0-1 Atlantic sturgeon in the fall and comparisons to annual dissolved oxygen levels during the preceding summer months provide additional evidence that low dissolved oxygen levels are causing or contributing to the death of the young sturgeon in the Delaware River in some years (Moberg and DeLucia 2016; Stetzar et al. 2015; Park 2020). On December 1, 2022, the EPA issued a determination that revised Water Quality Standards are necessary for the Delaware River Estuary to meet the requirements of the Clean Water Act. Specifically, the EPA determined that the aquatic life designated uses and corresponding dissolved oxygen criterion in Zones 3, 4, and RKM 126.8 to 112.7 (RM 78.8 to 70.0) of Zone 5 of the Delaware River Estuary must be revised to protect the propagation of resident and migratory fish species, including

Atlantic and shortnose sturgeon, which are likely experiencing adverse effects under the currently applicable Water Quality Standards that were established in 1967.

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/RM 148). Based on documented habitat use by various life stages of shortnose sturgeon in the Delaware River, young-of-the-year, juveniles, and adults of this species are expected to occur near the proposed Port (i.e., eggs and larvae of shortnose sturgeon are not likely to occur there because of salinity levels) (NMFS 2014).

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 (Altenritter *et al*. 2017, Wippelhauser *et al*. 2015). 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). 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 Port 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 (13.7 mi) 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 (59°F), although sturgeon have been reported on the spawning grounds at water temperatures as high as 18ºC (64.4°F).

Eggs, larvae

Shortnose sturgeon eggs adhere to the substrate quickly 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 sac 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 (164 ft) downstream of the I-95 bridge (approximately RKM 195/RM 121) in April and May of 2007 and 2008.

In general, we have very little information about shortnose sturgeon post yolk sac larvae distribution in the Delaware River. However, larvae do not tolerate saline water. Shortnose sturgeon eggs and larvae have been collected in the non-tidal Delaware River from immediately upriver of the Trenton rapids to the Lambertville rapids (ERC, 2008, 2015). There are only two records of shortnose sturgeon larvae being collected in the upper tidal Delaware River, between RKM 204-212 (RM 126.8-131.7), during approximately the same time period. The SSSRT (2010) speculated that these may have been anomalous occurrences caused by a high river flow event that flushed the larvae out of the non-tidal river. 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 (RM 67 and 76), which is within and slightly upstream of the action area. Based on the information above, shortnose sturgeon early life stages may be present within the upper portion of the action area if the salinity does not exceed their tolerance levels.

Juveniles

Young-of-the-year 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 12 to 13.7 m (40 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 occurred (e.g., NMFS 2015, 2019b). The relocation trawls collected several young-of-the-year 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 young-of-the-year in December indicates that downstream migration from spawning sites 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 (<20 inches) Fork Length) represented from 9 percent 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 (RM 67 to 76) (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 during late fall to January (ERC 2007). Further, the BA for another consultation in this region (ERC 2020b) provided the results of tracking studies, which indicate that during the winter months juvenile shortnose sturgeon are more widely distributed in the Delaware River and likely closer to 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 2020b). Based on telemetry data collected on acoustic receivers in the vicinity of the Edgemoor-Penns Grove region (Figure 5), juvenile shortnose sturgeon were detected in greatest abundance in the spring (i.e., April through May) and winter (i.e., December through January) and were detected in lowest abundance or not detected in February or July through September (Figure 5). Only 10 percent of tagged juveniles were detected near that project site (the proposed Edgemoor Container Port). As with juvenile and subadult Atlantic sturgeon, telemetry data indicated that juvenile shortnose sturgeon were more commonly observed upstream of the proposed Port only making seasonal excursions downriver to the reach adjacent to the proposed Port (Figure 5).

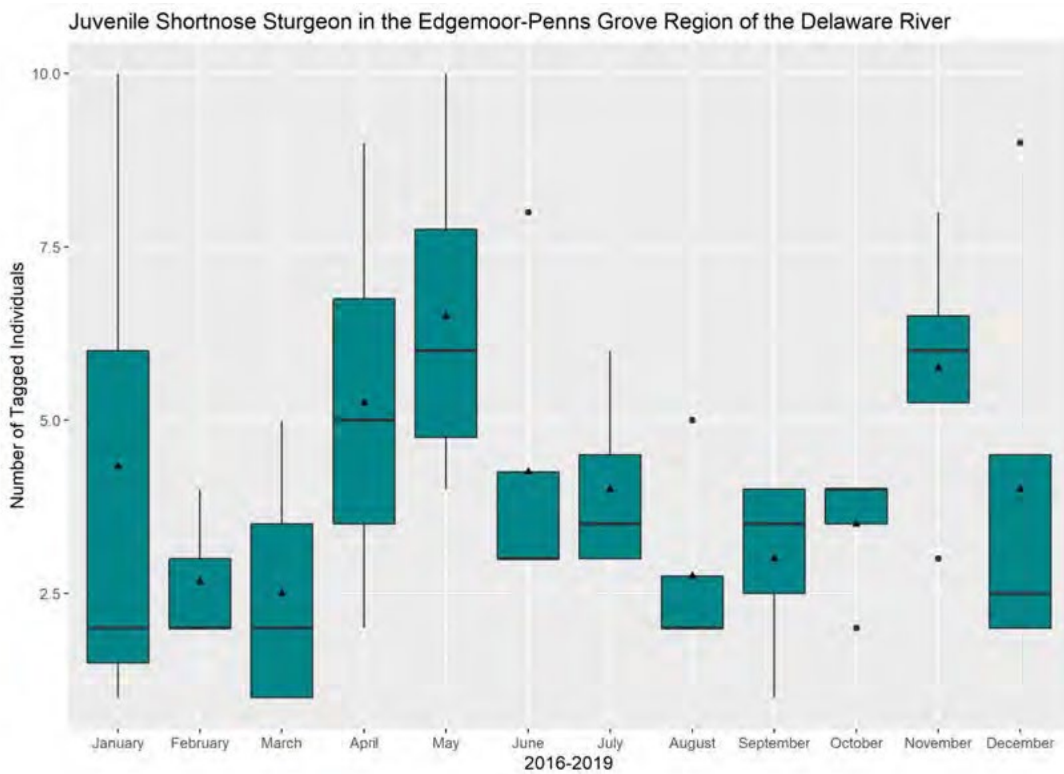


Figure 5. Number of acoustically tagged juvenile shortnose sturgeon detected in the Edgemoor-Penns Grove region of the Delaware River, by month, all years combined

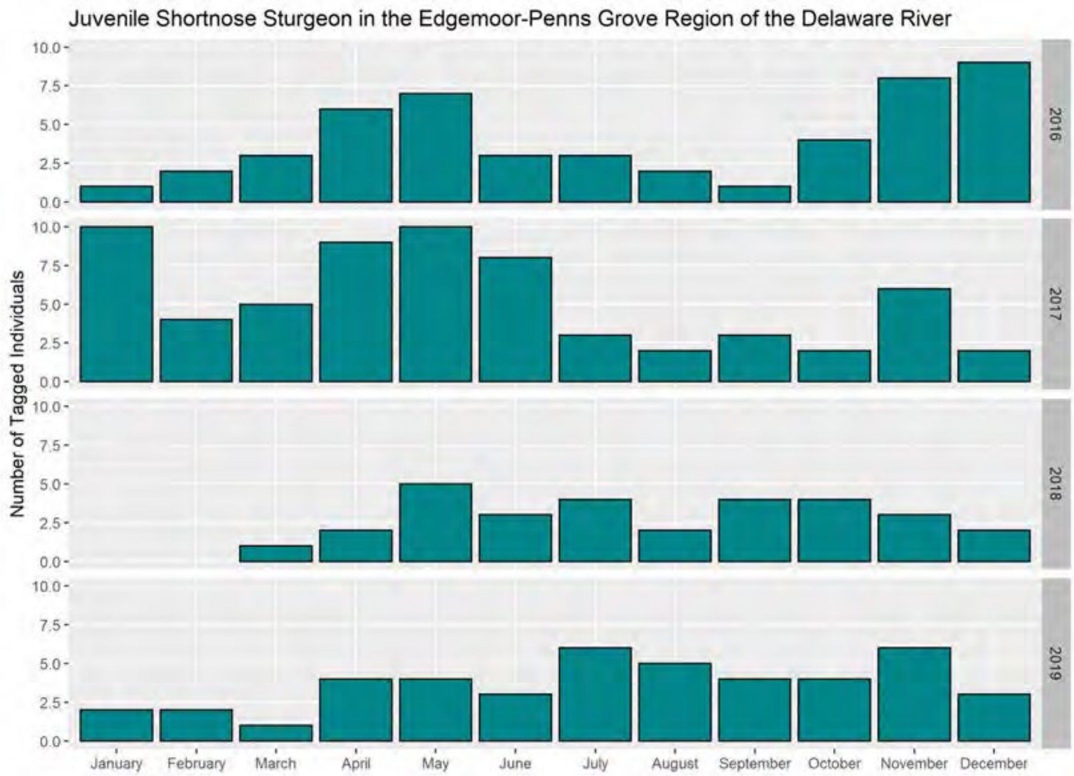


Figure 6. Number of acoustically tagged juvenile shortnose sturgeon detected in the Edgemoor-Penns Grove region of the Delaware River, by month and year

Adults

After spawning, which occurs during spring months and ceases by the time water temperatures reach 15ºC (59°F) (although sturgeon have been reported on the spawning grounds with water temperatures as high as 18ºC (64.4°F)), shortnose sturgeon move rapidly downstream to the Philadelphia area (~RKM 161/RM 100). After adult sturgeon migrate to the area around Philadelphia, many adults return upriver to between RKM 204 and 216 (RM 127 and 134) 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 action area. This area may serve as a summer aggregation site.

By the time water temperatures have reached 10°C (50°F), typically by mid-November[11], 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 (RM 125 and RM 148) as presented by Brundage (1986). Based on water temperature data collected at the USGS gage at Philadelphia, in general,

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

shortnose sturgeon are expected to be at the upstream overwintering grounds between RKM 190 and 211 (RM 118 and 131) 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, New Jersey (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/RM 51.6), and moved upriver to the Deepwater Point Range (RKM 105/RM 65) in mid-January where it remained until it moved rapidly to Marcus Hook (RKM 130/RM 81) on March 12. Shortnose sturgeon 2950 was tracked through February 2, 2007. In December the fish was located in the Bellevue Range (RKM 120/RM 74.6). Between January 29 and February 2, the fish moved between Marcus Hook (RKM 125) and Cherry Island (RKM 116/RM 72). Shortnose sturgeon 2953 also exhibited significant movement during the winter months, moving between RKM 123 and 163 (RM 76.4 and 101) from mid-December through mid-March. Tracking of adult and juvenile shortnose sturgeon captured near Marcus Hook (RKM 127-139/RM 79-86) and relocated to one of three areas (RKM 147, 176 and 193/RM 91, 109 and 120) demonstrated extensive movements during the winter period.

Telemetry data for adult shortnose sturgeon indicate that adults display similar seasonality as juveniles (ERC 2020b). Adults are most abundant in the Edgemoor-Penns Grove region during April to June and occur at lower abundance in January and February (Figure 7). Adult shortnose sturgeon are generally least abundant or not present from July through September and February through March. Twenty one percent of tagged adult shortnose sturgeon were acoustically detected in the vicinity of the Port. 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 7).

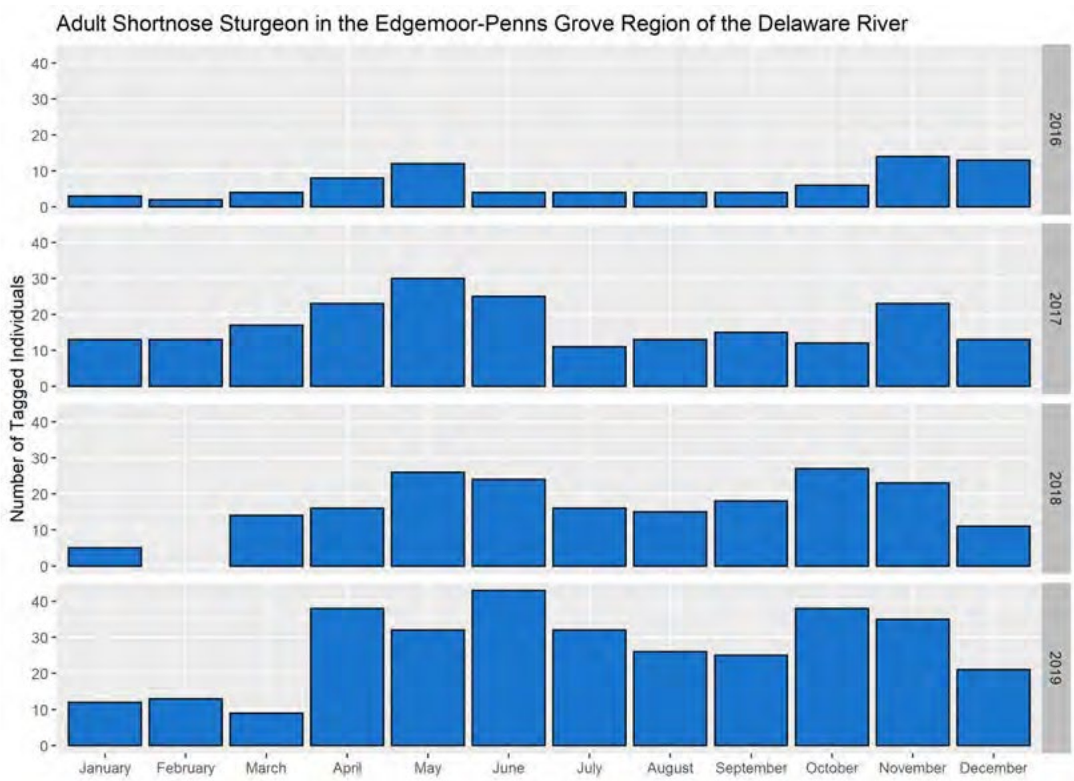


Figure 7. Number of acoustically tagged adult shortnose sturgeon detected in the Edgemoor-Penns Grove region of the Delaware River, by month and year

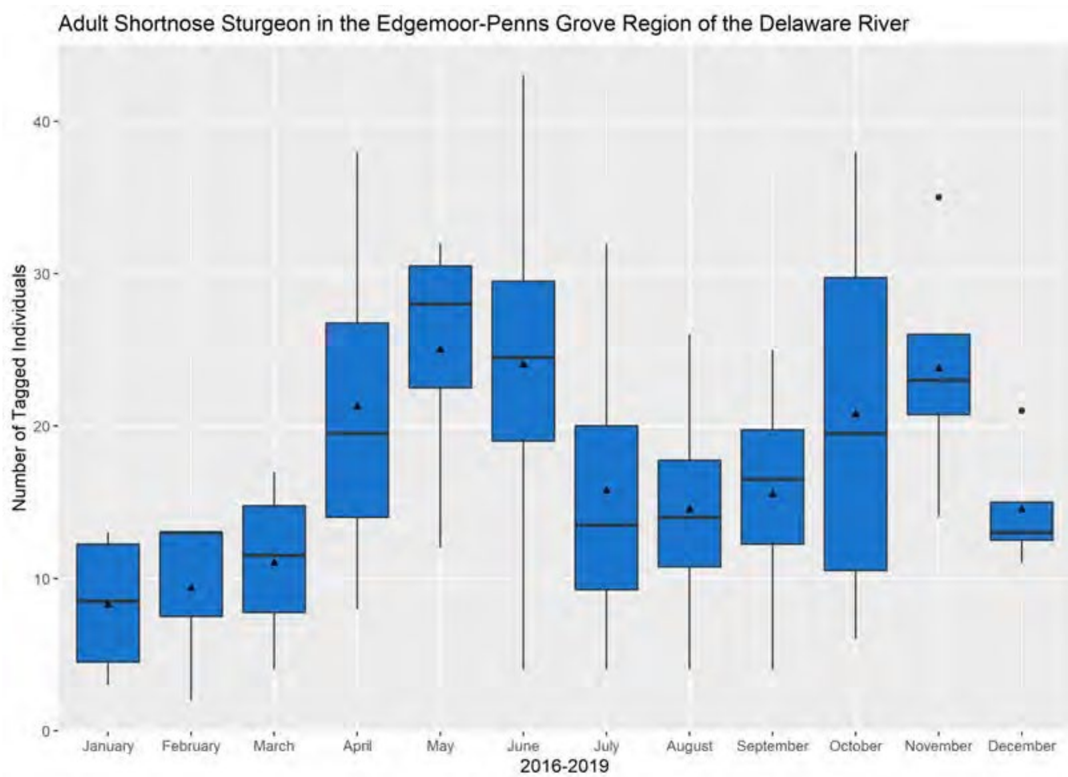


Figure 8. Number of acoustically tagged adult shortnose sturgeon detected in the Edgemoor-Penns Grove region of the Delaware River, by month, all years combined

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, Pennsylvania. 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 young-of-the-year, 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.

Port Site Reach - 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 it was an area frequented by shortnose sturgeon. This area also includes the outlet of the Chesapeake-Delaware canal, where shortnose sturgeon have been documented 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. A review of available literature found only one record of a shortnose sturgeon in Brandywine Creek. Raasch (2007) reported that a 0.6 m (2 ft) (adult) shortnose sturgeon was caught by a fisherman at the base of Dam 1 on July 5, 1955. No other documented occurrences have been noted since.

Lower Estuary - Mesohaline: RKM 78-92 (RM 48.5-57), 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 within this 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 (Action Area): 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 (RM 31) between late April and mid-November. Due to the typical high salinities experienced in the polyhaline zone (below RKM 50/RM 31), 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, New Jersey, a distance of almost 220 km (136.7 mi) (Hilton *et al.* 2016, Simpson 2008). An Atlantic sturgeon carcass was found at Easton, Pennsylvania (i.e., above the fall line of the Delaware River) in 2014 (NMFS 2017) suggesting that Atlantic sturgeon can move past the fall line. However, tracking and tagging information support that the fish typically occur downriver of the fall line (NMFS 2022).

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 tidal habitat are available to Atlantic sturgeon compared to pre-industrial times.

Spawning

Spawning may occur from April to July (ASSRT 2007, NMFS 2022). 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 (RM 48 and 81) (Delaware City, Delaware to Chester City, Pennsylvania). However, based on tagging and tracking studies, current Atlantic sturgeon spawning may occur upstream of the salt front over hard bottom substrate between Claymont, Delaware/Marcus Hook, Pennsylvania (Marcus Hook Bar), approximately RKM 125 (RM 78), and the fall line at Trenton, New Jersey, approximately RKM 212 (RM 132) (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 young-of-the-year in the Delaware River provides confirmation that regular spawning is still occurring in this river.

Based on previous studies, the likely spawning area in the lower tidal river closest to the Port site is located between the Marcus Hook Bar (RKM 125/RM 78) and the downstream end of Little Tinicum Island (RKM 138/RM 86). 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). The entrainment of a yolk sac larva at the cooling intake of the Eddystone Generating Station in 2017 (NMFS 2020) confirms that spawning occurs 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 because the closest known spawning area is approximately 7 km (4.3 mi) upstream.

Atlantic sturgeon eggs are adhesive and stick to the substrate. Therefore, eggs will remain at or near the site where the female releases them 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). Post yolk-sac larvae (stage when the larva has exhausted the yolk-sac and is free moving) initiated downstream movement in the simulated river drift that lasted for 6-12 days, which would be sufficient to transport the larvae from spawning to rearing areas without entering salt water (Kynard and Horgan, 2002). It appears likely that Atlantic sturgeon larvae in the Delaware River drift for only a short period, since long duration drift from the presumed spawning areas would transport the larvae into waters of higher salinity, where they would not survive. As with the larvae of other sturgeon species, Atlantic sturgeon have likely evolved river/population specific patterns of dispersal that result in their movement downriver from spawning areas to optimal rearing areas upriver of the salt front (Hilton *et al*., 2016).

There is no information about post yolk-sac larvae 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). It is presumed that the Atlantic sturgeon spawning reach in the lower tidal Delaware River (RKM 125-137 (RM 77.7-85)) overlaps with the area of greatest abundance of young-of-the-year Atlantic sturgeon (RKM 123-129 (RM 76.4-80)), which suggests that post yolk-sac larvae dispersal is minimal. Based on this information, as well as what is known about post yolk-sac larvae, Atlantic sturgeon early life stages, such as eggs and larvae are not present in either the river near Edgemoor where the Port will be located, or the mitigation sites.

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, New Jersey. Within the lower estuary, juveniles are present in the river off Edgemoor 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.

Young-of-the-year Atlantic sturgeon nurse in the Delaware River below Little Tinicum Island to just upstream of the salt front. Sampling in 2009 targeted young-of-the-year and resulted in the capture of more than 60 young-of-the-year in the Marcus Hook anchorage (RKM 127/RM 79) area during late October through late November 2009 (Calvo *et al.* 2010, Fisher 2009). Two telemetry studies of young-of-the-year with acoustic tags showed that young-of-the-year use several areas from Deepwater (RKM 105/RM 65) to Roebling (RKM 199/RM 124) 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 young-of-the-year spent some time downstream of Marcus Hook (Calvo *et al.* 2010, Fisher 2011). Downstream detections from May to August between Philadelphia (RKM 150/RM 93) and New Castle (RKM 100/RM 62) suggest non-use of the upriver locations during the summer months (Fisher 2011). Similarly, Hale et al. (2016) captured age 0-1 year old sturgeon in the Delaware River in 2014, and passively tracked these for several months. During that time, the Marcus Hook area served as an important nursery ground but the sturgeon also used habitats as far upriver as RKM 152 (RM 94.4) and as far downriver as RKM 99 (RM 61.5) (Hale *et al.* 2016). Based on this, it is likely that young-of-the-year 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/RM 76-80) and Cherry Island Flats (RKM 112-118/RM 70-73.3) 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. For one-year old juveniles and older, most detections occurred in the lower tidal Delaware River from the middle Liston Range (RKM 70/RM 43.5) to Tinicum Island (RKM 141/RM 87.6). For non- young-of-the-year 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).

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 Delaware River deepening project. Telemetry data from 2016 to 2019 indicate that acoustic-tagged juvenile Atlantic sturgeon occur in the vicinity of the Project area throughout the year, based on acoustic detections at receivers in the vicinity of Edgemoor (Figure 9). However, their utilization of the area varied seasonally. The number of days spent in the Edgemoor-Penns Grove region per individual was somewhat greater during the summer (July-August) months and the number of transmitter pings detected was highest during May through July (Figs. 9 and 10). The greatest number of juvenile sturgeon were detected between April and June and in October and November (Figure 10). Of the 287 acoustic-tagged Atlantic sturgeon at large in the Delaware River, approximately 69 percent were detected in the vicinity of Edgemoor at some point during the monitoring.

In general, within the Delaware River, the distribution of juvenile Atlantic sturgeon is centered on the Marcus Hook-Chester ranges (RKM 121-136/RM 75-84.5), consistent with earlier acoustic tracking studies (Brundage and O'Herron, 2009; Brundage *et al*., 2014; Hale *et al*., 2016).

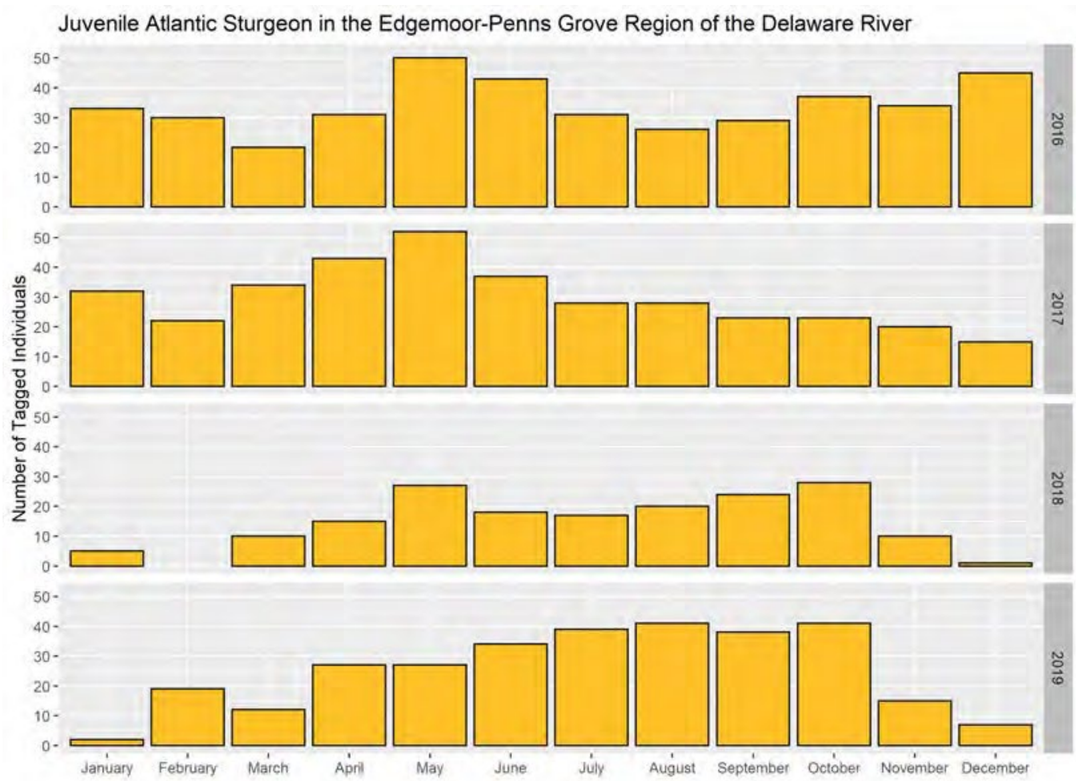


Figure 9. Number of acoustically tagged juvenile Atlantic sturgeon detected in the Edgemoor-Penns Grove region of the Delaware River, by month and year

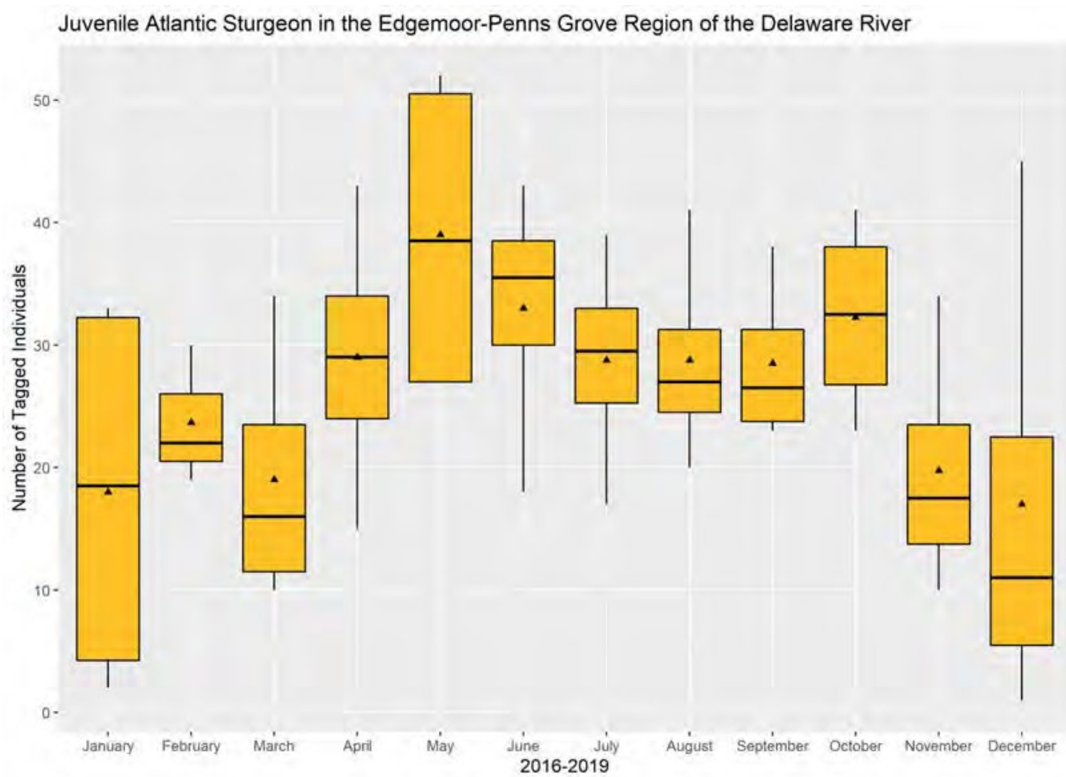


Figure 10. Number of acoustically tagged juvenile Atlantic sturgeon detected in the Edgemoor-Penns Grove region of the Delaware River, by month, all years combined

Adults and Subadults

Adult and subadult (natal and 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 (New York Bight adults only). Adults and, especially, subadults occur and reside in lower estuary 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 suggests 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.* 2012c, 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), Delaware Bay, and near coastal areas are used by sturgeon from multiple DPSs (Busch 2022, Damon-Randall *et al.* 2013, White *et al.* 2021, Wirgin *et al.* 2015a). For Atlantic sturgeon occurring in the Delaware River, there are no extensive genetic studies of non-Delaware River native fish relative to Delaware River natal fish.

Damon-Randall *et al.* (2013)presented data for fish found in the spawning region of the Delaware River where approximately 38 percent (3 fish) was not of New York Bight DPS origin but they noted that the data was limited to only eight fish. Therefore, they suggested that the more data rich Hudson River studies of stock composition where approximately 92 percent of the Atlantic sturgeon were identified as being New York Bight fish should also be used for the Delaware River. This is because they assumed that because spawning Atlantic sturgeon have high fidelity to their natal river, the majority of adult and subadult Atlantic sturgeon would be from the Delaware River and, therefore, New York Bight DPS fish. However, contrary to this assumption, a recent study found that about ten times more tagged non-native Atlantic sturgeon entered the Delaware River than tagged fish genetically assigned as natal to the Delaware River. The proportion of natal Atlantic sturgeon entering the Delaware River (approximately at RKM 78 (RM 48.5)) was not significantly different from the proportion of Delaware River origin fish from aggregations in the Delaware Bay and nearshore areas off Delaware State (Busch 2022). However, telemetry showed that the genetically assigned Delaware River Atlantic sturgeon commonly traveled upstream to and above 68.8 km (42.8 mi) while the average furthest distance traveled by non-Delaware native fish was 18 km (11.2 mi). In other words, Atlantic sturgeon natal to the Delaware River commonly traveled past the Edgemoor Container Port while non-native fish mostly remained in the lower saline estuary below Pea Patch Island (RKM 96/RM 60) downstream of the Port (Busch 2022).

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/RM 62) to Little Tinicum Island (RKM 138/RM 86) though adult Atlantic sturgeon were detected as far upstream as Roebling, New Jersey (RKM 201/RM 124.9) (Fox *et al.* 2015). The earliest detection was in mid-April while the latest departure occurred in mid-June, which supports 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 an 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 use depths between 10 and 50 m (33 and 164 ft) and most captures occur at depths of 20 m (65 ft) 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 *et al.* 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 *et al.* 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, New Jersey, 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 June. 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 young-of-the-year and young juveniles. The reach also includes likely Atlantic sturgeon spawning sites along the edge of the navigation channel. The best available information suggests spawning occurs primarily from May-June (ASMFC 2017). However, there is annual variation in movements of adults to and from the spawning reach related to water temperature and possibly other environmental factors. Adults can start moving upriver as early as April and some adults may be upriver as late as July (Breece *et al*. 2013). Therefore, to ensure that we are considering all of the possible effects of the proposed action, we consider that spawning could occur as early as April and as late as July. Depending on when spawning occurs, post yolk sac larvae may occur throughout the reach above the salt front from April through July.

Port Site Reach - 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, which Atlantic sturgeon may use to move between the upper Chesapeake Bay and the Delaware River. Early life stages are unlikely to be present because of their intolerance of higher salinity levels. 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. This area includes the Port and mitigation sites. Adults use the channel for spawning migration from April through July. There are no records of Atlantic sturgeon in Brandywine Creek or the Christina River.

Lower Estuary - Mesohaline: RKM 78-92 (RM 48.5-57), includes the area near 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 within the 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 Sea Federal Navigation Channel from RKM 78 to RKM 5 (RM 48.5 to RM 3.1), 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. 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. Although it is possible for subadults and adults to be present at the Bay mouth and in its near shore waters year round, it is unlikely that they are present during winter months (see Rothermel *et al*. 2020, Breece *et al*. 2018, and Erickson *et al.* 2011). Mature adults migrating to spawning in the Delaware River belong to the New York Bight DPS, but subadults and non-mature adults may belong to multiple DPSs.

6.2.2.3 Determination Adult and Subadult Age Classes in the Action Area

We reviewed sturgeon carcasses reports available to us from the Delaware River and Bay to calculate the number of adult and subadult New York Bight Atlantic sturgeon. The carcass reporting rate calculated by Fox *et al*. (2020) included both adult and subadult sturgeon (section 6.7.4.2), but did not differentiate different rates for different life stages; separate reporting rates for life stages do not exist. In addition, we may have underestimated the percentage of adults in the carcass data as we used a total length of 150 cm (59 in) to distinguish adults while several studies have shown that Atlantic sturgeon may mature at shorter lengths. To separate the number of adult and subadult takes, we need an estimate of vessel strike mortality by life stage.

The best available information to calculate this rate are the Atlantic Sturgeon Carcass Databases provided by DNREC and NJFW. The list of sturgeon was limited to those whose cause of death was identified as “vessel strike” or “unknown,” the list was further limited to those with enough of a body to identify approximate length (or enough of a body to identify maturity stage where possible). For this qualitative analysis, subadults ranged from 76-150 cm (29.9-59 in) and juveniles are less than 76 cm (29.9 in), unless identified as a different stage by the sturgeon biologist in the database.

Table 17. Sturgeon vessel strike mortality by life stage in the Delaware River and Bay

Stage	All Sturgeon (n)	All Sturgeon (%)	DNREC Sturgeon (n)	DNREC Sturgeon (%)
Adult	50	56.18	44	56.41
Subadult	20	22.47	15	19.23
Juvenile	19	21.35	19	24.36

With the life stage rates derived from the Vessel Strike Database, we simply apply stage-specific rates to the estimates of takes as follows:

$$N_{stage} = N * S_{stage}$$

where N_{stage} is the number of sturgeon of a particular life stage killed over the operational period of a project, N is the total number of sturgeon killed over the operational period of a project, and S_{stage} is the percentage of sturgeon mortalities by life stage killed in the Delaware River and Bay by vessel strike.

6.2.2.4 Determination of DPS Composition in the Action Area

The action area includes 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, also thereby, in the action area, will have originated from the Delaware River and belong to the New York Bight DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the action area would not be limited to only individuals originating from the New York Bight DPS. With respect to the river of origin, we have limited information from which to determine the percentage of New York Bight DPS adult and subadult fish within the action area that are likely to originate from the Delaware River versus the Hudson River.

The range of all five listed DPSs extends from Canada through Cape Canaveral, Florida. The most recently published mixed stock analysis (Kazyak *et al.* 2021) found that 37.5 percent of individuals sampled from the mid-Atlantic region (Cape Hatteras to Cape Cod) were assigned to populations in the New York Bight DPS. While the study by Kazyak *et al.* (2021) reflects an improvement in genetic approaches, we decided not to use the reported DPS frequencies because they were based on genetic sampling of Atlantic sturgeon that were encountered throughout the U.S. Atlantic coast. A recent (2022) master's thesis conducted a mixed stock analysis of tissue samples collected from adult and subadult Atlantic sturgeon caught in the Delaware River Estuary, Delaware Bay, and in coastal waters off Delaware (Busch 2022). The study found that 51 percent of adult and subadult Atlantic sturgeon sampled were of NYB DPS origin. This percentage as well as the percentages of the other DPSs were similar to what Damon-Randall *et al.* (2013) reported for their Marine Mixing Zone 2, which included Atlantic sturgeon sampled in marine areas from Chatham to Cape Hatteras. However, Damon-Randall *et al.* (2013) recognized that the mixed stock of Atlantic sturgeon found in the lower river/upper estuary area may differ from that reported in marine off-shore waters. Based on this, they also produced mixed stock assessment for estuarine/riverine zones (E/RMZ) that extended from the coastline up to the furthest extent of sturgeon migration in non-spawning rivers and up to the 0.5 parts per thousand (ppt) salinity threshold in spawning rivers. The NEFSC reviewed available mixed stock assessments, including Damon-Randall *et al.* (2013), and concluded that the E/RMZ 3 for the New York Bight and Chesapeake Bay should be used for consultations within the Delaware River Estuary and Delaware Bay.

The action area for this consultation includes the Delaware River from its mouth upstream to approximately RKM 118 (RM 73.3). The DPS composition of subadults and adults entering the river and traveling upstream may be different from that in estuarine, bay, and marine areas. Busch (2022) found that Atlantic sturgeon subadults and adults that do not originate from the Delaware River mostly do not travel upstream past RKM 96 (RM 60) and Damon-Randall *et al.*

(2013)previously suggested using results from Hudson River as an estimate of in-river DPS proportions. Thus, E/RMZ3 from (Damon-Randall *et al.* 2013) may not reflect the DPS composition of adults and subadults in the freshwater tidal reach of the Delaware River. Based on Busch (2022) and Damon-Randall *et al.* (2013), we expect that a large majority of Atlantic sturgeon in that portion of the river where the Port is located would be of Delaware River origin. The remaining portion of the action area, consists of the Federal Navigation Channel through the lower and more saline estuary, the Delaware Bay, and the immediate coastal area off the bay's mouth where genetic and telemetry studies have identified aggregations of multiple DPSs. Thus, we believe that the E/RMZ3 better reflects the stock composition in the areas where vessels calling at the Port will travel through during its operation and that it is the best available information to determine stock composition in this portion of the action area.

Based on the E/RMZ 3 mixed-stock analysis by Damon-Randall *et al.* (2013), 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 13 percent; New York Bight 42 percent; Chesapeake Bay 24 percent; South Atlantic 20 percent; and Carolina 1 percent. We rely on Damon-Randall et al. (2013) because the DPS percentages are largely based on genetic sampling of individuals sampled in directed research targeting Atlantic sturgeon along the Delaware Coast, just south of Delaware Bay and the spawning zone in the Hudson and Delaware Rivers (described in detail in Damon-Randall *et al.* 2013). More recently, Busch (2022) and Wirgin *et al*. (2015) found similar breakdowns of fish on the Delaware Coast, Bay, and River where fish were sampled; however, 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.

The genetic assignments have a plus/minus 5 percent confidence interval; however, for purposes of the 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. The Carolina DPS is the exception as its confidence interval for the E/RMZ 3 range from 0 to 6 percent.

Carolina DPS origin fish have rarely been detected in samples taken in the Northeast. Wirgin *et al*. 2015 and Busch 2022 identified Carolina DPS sturgeon in the samples that were collected on the Delaware Coast or, in the case of Busch 2022, the Delaware Coast, Bay, and River. 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, two 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 (Damon-Randall *et al.* 2013). 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 one (1) percent of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. The assignments above and the data from which they are derived are described in detail in Damon-Randall *et al.* (2013).

6.2.2.5 Determination of New York Bight River Composition in the Action Area

We have reviewed mixed stock analyses available to us that included river distribution in their DPS determinations. These studies support the notion that the Hudson River spawning population is the more robust of the two spawning populations. 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 (Busch 2022, Kazyak *et al.* 2021, Wirgin *et al.* 2015a, Wirgin and King 2011). Wirgin *et al.* (2015b), which sampled migrating Atlantic sturgeon from an area 3 to 12 km (1.9 to 7.5 mi) from the Delaware coast, found that 10.6 percent of all the fish sampled were from the Delaware River and 44 percent were from the Hudson River. Kazyak *et al.* (2021) found that 37.5 percent of individuals sampled from the mid-Atlantic region (Cape Hatteras to Cape Cod) were assigned to populations in the New York Bight DPS. For the total sample, 11.4 percent were Delaware River fish and the remaining 26.2 percent were Hudson River fish. However, the sample seems to include juveniles (defined as <500mm TL) from the Delaware River and, therefore, may reflect an overrepresentation of Delaware River origin fish because juveniles do not leave their natal estuary, which is where some sampling must have occurred. A recent (2022) master's thesis conducted a mixed stock analysis of tissue samples collected from adult and subadult Atlantic sturgeon caught in the Delaware River estuary, Delaware Bay, and in coastal waters off Delaware (Busch 2022). The study found that 8.3 percent of all fish samples were Delaware River fish and 41.8 percent were Hudson River fish.

For this Opinion, we have calculated the average river distribution result from the studies described above and applied it to the New York Bight Atlantic sturgeon within the action area to estimate the rivers of origin. In the studies described above, New York Bight DPS fish represented 54.6 percent, 37.5 percent, and 51 percent of the individuals sampled. We then estimated the percentage of Delaware and Hudson River fish that comprise the fraction of all New York Bight DPS Atlantic sturgeon in the action area based on those studies' results. We calculated 23 percent as the average percentage of Delaware River fish and 77 percent as the average percentage of Hudson River fish occurring throughout the action area.

6.2.2.6 Delaware River Critical Habitat Unit

As noted in section 4.1.3, the action area considered in this biological opinion includes the Federal Navigation Channel from the mouth of the Bay (RKM/RM 0) to RKM 118 (RM 73.3), the mitigation sites, 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 214/RM 133) downstream to where the river discharges into Delaware Bay at RKM 78 (RM 48.5). Thus, the action area overlaps with critical habitat within the Delaware River and contains PBFs 2, 3, and 4.

The Delaware River Basin Commission (DRBC) defines the salt front as the area in the river where the water registers 250 milligrams 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 (RM 67 to RM 76) (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 upper reaches of the river. DRBC (2017) identifies RKM 107.8 to RKM 122.3 (RM 67 to RM 76), as the median range for the salt front (defined as 0.25 ppt); the historic salt front location is reported as approximately RKM 92 (RM 57). 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 (RM 44 and 79) 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 16 km (~10 mi) in a day due to semi-diurnal tides, and by more than 32 km (~20 miles) 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, the area within and upstream of RKM 107.8 (RM 67) to RKM 122.3 (RM 76) may have salinity levels consistent with the requirements of PBF 1, which overlaps the action area depending on where the salt front is in a particular year; however the substrate in the action area is not characterized as hard bottom. As such, PBF1 does not occur in 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, the soft substrate component of 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 historic salinity transition zone occurs from RKM 91.9 to RKM 93.9 (RM 57.1 to 58.4) and DRBC (2017) identifies RKM 107.8 to RKM 122.3 (RM 67 to RM 76), as the median range for the salt front.

In the Delaware River we consider PBF 2 to occur from approximately RKM 78 (RM 48.5) (where the final critical habitat rule describes the mouth of the river) to between RKM 107.8 and RKM 122.3 (RM 67 to RM 76), or the 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 the transitional zone between RKM 107.8 and RKM 122.3 (RM 67 to RM 76) is a reasonable approximation given the lack of real time data. As such, the Philadelphia to the Sea Navigation Channel from RKM 78 to RKM 118 (RM 48.5 to RM 73.3) overlaps with the area where PBF 2 occurs. We estimate the total area of critical habitat (bank-to-bank in the mainstem of the river between RKM 78 and 118/RM 48.5 and 73.3) to be 34,240 acres. The action area within PBF 2 consists of the Navigation Channel and the Port, which we estimate to be an area of 2,230 acres and 935.5 acres, respectively, between the mouth of the river (RKM 78/RM 48.5) and the upstream end of the PBF 2 (RKM 118/RM 73.2). The various acreages are presented below:

Feature	Acreage
River channel between RKM 78 and 118 bank to bank	34,240
Navigation Chanel between RKM 78 and 118	2,230
Port Action Area	935.5

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/RM 43.5) to Tinicum Island (RKM 141/RM 87.6)(Calvo *et al.* 2010). Juveniles tracked in this study ranged in size. Older, larger juveniles (average 716 mm, range 505-947 mm) moved towards the Bay but were not detected below Liston Range. The smaller juveniles averaged 524 mm (range 485-566 mm).

Based on the best available information on the distribution of juveniles in the Delaware River, we generally expect that juveniles will occupy this area year round. Foraging is expected to occur over soft substrates that support the benthic invertebrates that juvenile Atlantic sturgeon eat. Juveniles are thought to forage year-round with the lightest foraging during the winter. The most active foraging in these areas likely occurs in the spring to fall months. Later in the fall, larger, late-stage juveniles likely move out of this transitional zone into more saline waters in the lower Delaware River estuary (without leaving the estuary altogether, as that would indicate a transition to the subadult life stage), while the younger juveniles remain and either continue foraging, or move upstream to winter aggregation areas, such as those documented near Marcus Hook (ERC 2016, 2017, 2018, 2019, 2020a, b).

Activities that may 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 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 at 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 from 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.

As noted above, we estimate that 34,240 acres potentially meet the criteria for PBF 2 between RKM 78 and RKM 118 (RM 48.5 and RM 73.3). The Port action area and the navigation channel in this same reach of the river encompasses an area of approximately 3165.5 acres. Therefore, up to 9.2 percent of the area where we expect PBF 2 to occur is subject to vessel disturbance (assuming all action area habitat in the Navigation Channel and Port in this reach meets the criteria for PBF 2).

As described in section 6.1, water pollution and contamination have historically been, and continue to be, an issue in the Delaware River, despite significant progress in limiting pollution and improving water quality in the past few decades. Point source discharges (i.e., municipal wastewater, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of benthic fauna consumed by foraging juvenile sturgeon in the transitional salinity zone. We consider the impacts of climate change in section 7.

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 (4 ft)) 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 118 (RM 48.5 to 73.3) 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 6.1.2). 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 of this Opinion, will likely lead to an upstream shift in the salt front resulting from rising sea levels. Salinity levels prevent spawning and rearing of early life stages 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), 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 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 has 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 -12 to -13.7 m (-40 to -45 ft) (with 0.6 m (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 -12 to -13.7 m (-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 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, the Gulf of Maine, New York Bight, Chesapeake Bay, and South Atlantic DPSs of Atlantic sturgeon, Kemp's ridley sea turtles, and loggerhead sea turtles. The biological opinion concluded that the proposed project was not likely to adversely affect Atlantic sturgeon from the Carolina DPS, green sea turtles, or leatherback sea turtles. We also determined that the proposed action is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon

Although listed whales occur seasonally off the Atlantic coast of Delaware and right whales occasionally transient 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 Port. The USACE maintains to -12 m (-40 ft) depth the Delaware River Navigation Channel from Allegheny Avenue in Philadelphia (RKM 176.9/RM 110) to Newbold Island in Bucks County (RKM 191.3/RM 119), north of Philadelphia. From there, the USACE maintains navigation channels of varying authorized depths to the upstream limit of the FNP (RKM 214.5/RM 133.3) just below the Penn-Central R.R. Bridge crossing over the Delaware River at Trenton, New Jersey. 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 18 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). The entrainment of shortnose sturgeon in the cutterhead dredge occurred during dredging in or near aggregation areas during winter. Since 1998, the USACE has 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 -12 m (-40 ft) 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 -12 m to -13.7 m (-40 ft to -45 ft) in 2020. Maintenance dredging of the -12 m (-40 ft) 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 -13.7 m (-45 ft) channel.

River reaches from AA to E divide the Philadelphia to the Sea FNP. Reach E is the downstream end of the channel in the Delaware Bay that starts at RKM 5 (RM 3) and the uppermost reach, Reach AA, ends at Allegheny Avenue in Philadelphia (RKM 176.9/RM 110). The Port access channel will connect with the Philadelphia to the Sea at Reach B (Figure 11).

Figure 11. Delaware River main channel deepening project

6.3.1.3 The Philadelphia to the Sea Deepening

Prior to completion of the deepening project, the USACE maintained the channel at a depth of 12m (40 ft) at MLLW. Only portions of the channel that were between 12 m and 13.7 m (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 transporting all sturgeon caught upriver near Trenton, New Jersey, where they were released.

The surface area of the Delaware estuary from the Ben Franklin Bridge to the capes (excluding tidal tributaries) is approximately 1,813 square kilometers (700 square miles). The Philadelphia to the Sea Federal Navigation Channel has a surface area of 39.6 square kilometers (15.3 square miles), or approximately 2.2 percent of the total estuary surface area, of which 22 square kilometers (8.5 square miles) has been dredged to 13.7 m (45 ft).

6.3.1.4 The Philadelphia to the Sea Maintenance Dredging

The USACE has maintained the Philadelphia to the Sea Channel at 13.7 m (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. A federally owned hopper dredge, other large hopper dredges, and hydraulic cutterhead dredges are also 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 2019a). Table 18 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 18. Philadelphia to the Sea 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	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 –

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
	Marine Terminal)								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 19. 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

6.3.1.5 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 New York Bight DPS.
- 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 (New York Bight DPS).
- 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 New York Bight 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 New York Bight 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. The consultation was completed in 2023 and a new biological opinion was issued on March 24, 2023. 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. Therefore, we rely on the ITS of the 2023 biological opinion.

As described in Table 20 through Table 23 below, the ITS of the Salem and Hope Creek Generation Stations 2023 biological opinion exempts take (injured, killed, capture or collected) of 32 shortnose sturgeon, 640 Atlantic sturgeon, and 4 loggerhead, 1 green, and 32 Kemp's ridley sea turtles resulting from the operation of the cooling water system. The ITS also exempts the capture of one live shortnose sturgeon and one live Atlantic sturgeon (originating from any of the 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 2023 biological opinion, we also determined that the UBMWP and REMP, required by the NJPDES permit issued to PSEG for the operation of Salem 1 and 2, including the bay-wide trawl survey, beach seine sampling, and gillnet sampling are a activitye caused by the proposed action. Thus, in the Effects of the Action section, we considered the effects of the UBMWP and REMP. We estimated that the continuation of the bottom trawl survey will result in the non-lethal capture of 13shortnose sturgeon, 17 Atlantic sturgeon (13 New York Bight, 3 Chesapeake Bay, and 1 South Atlantic, Gulf of Maine or Carolina DPS) and 3 sea turtles (2 loggerheads and 1 Kemp's ridley or green). We also expect the beach seine survey to result in the non-lethal capture of one Atlantic sturgeon (likely New York Bight DPS origin), one shortnose sturgeon, and one sea turtle. Finally we anticipate the capture of one shortnose sturgeon and one Atlantic sturgeon (originating from any of the 5 DPSs) during gillnet sampling associated with the REMP programs for either Salem 1, Salem 2, or Hope Creek. The ITS exempts this amount of take ("capture" or "collect") of live shortnose sturgeon, Atlantic sturgeon and sea turtles incidentally captured during these surveys.

Table 20. Salem and HCGS - Impingement or Collection of Shortnose Sturgeon at the Trash Bars.

Salem Unit 1	**Salem Unit 2**	**Total Unit 1 and 2**
14 (10 dead, 5 due to impingement)	18 (13 dead, 6 due to impingement)	32 (23 dead, 11 due to impingement)

Table 21. 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	112 (67 dead,43 due to impingement)	144 (85 dead, 55 due to impingement)	256 (152 dead, 98 due to impingement)
Non-migrant subadults or juveniles (i.e., TL 760 mm or less) (NYB DPS)	61 (36 dead, 24 due to impingement)	78 (47 dead, 31 due to impingement)	139 (83 dead, 55 due to impingement)
Subadult or adult TOTAL:	51 (31 dead, 20 due to impingement)	66 (39 dead, 25 due to impingement)	117 (70 dead, 45 due to impingement)
Sub adult or adult NYB DPS	37 (22 dead, 15 due to impingement)	47 (28 dead, 18 due to impingement)	84 (50 dead, 32 due to impingement)
Sub adult or adult CB DPS	9 dead or alive	11 dead or alive	20 dead or alive
Subadult or adult SA DPS	4 dead or alive	5 dead or alive	9 dead or alive
Subadult or adult GOM DPS	1 dead or alive	1dead or alive	2 dead or alive
Subadult or adult Carolina DPS	3 dead or alive	4 dead or alive	7 dead or alive

Table 22. 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	168 (14 injury or mortality)	216 (18 injury or mortality)	384 (32 injury or mortality)

Table 23. Sale and HCGS - Impingement/Collection of Sea Turtles at the Trash Bars.

Sea Turtle Species	**Salem Unit 1**	**Salem Unit 2**
Loggerhead	2	2
Green	One at Unit 1 or Unit 2 (alive or dead)	
Kemp's Ridley	14	18

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 2017a). Thus, the port is located outside of the action area for this consultation. However, the biological opinion considered the consequences of vessel 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 265 m (870 ft) and 9 to 12 m (30 to 40 ft) 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 Port 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 result in the destruction or adverse modification of critical habitat. 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 New York Bight DPS, one to the Chesapeake Bay DPS, and one from either the South Atlantic DPS or the Gulf of Maine 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 reinitiation 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-inch to 48-inch 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 USACE NLAA determination.

6.3.4 New Jersey Wind Port

On February 28, 2022, we issued a biological opinion to the USACE for the development by the Public Service Enterprise Group (PSEG) of a marshaling 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 proposed Port is located on the east bank of the Delaware River within the greater estuary at approximately RKM 84 (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.[12] The proposed Port will occupy approximately 30 acres of the PSEG property, immediately to the south of USACE CDF Cell No. 3. The project site lies between the New Jersey shoreline and the Philadelphia to the Sea Federal Navigation Channel (Figure 12), located approximately 2,000 m (6,600 ft) west of the shoreline and maintained at approximately 13.7 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.

[12] 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 was completed on March 24, 2023.

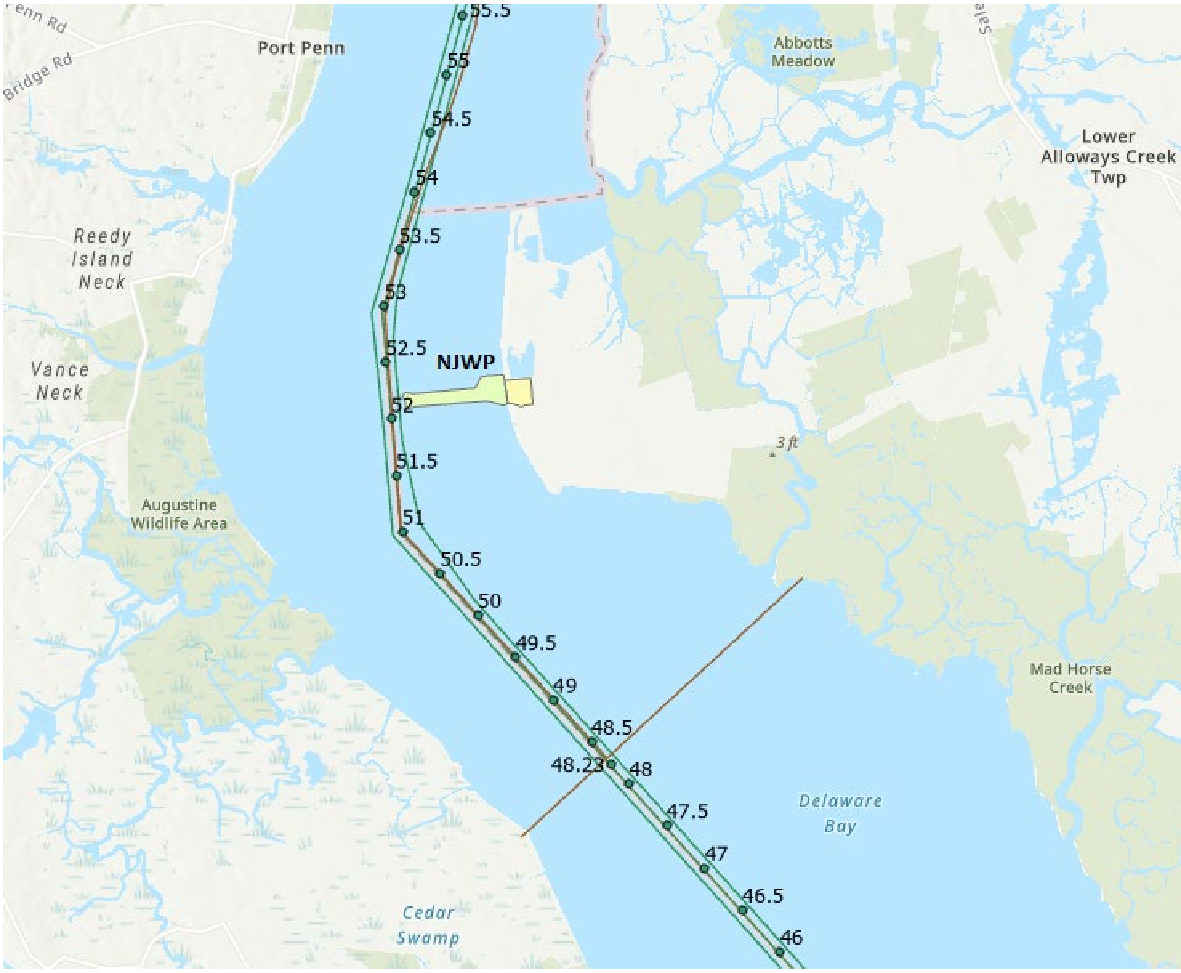


Figure 12. New Jersey Wind Port Development Boundary. The line across the channel is the location of the Delaware River mouth.

In the biological opinion, we concluded that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon, the Gulf of Maine, New York Bight, Chesapeake Bay, and South Atlantic DPSs of Atlantic sturgeon. We concurred that the consequences of the construction and operations of the facility were not likely to adversely affect listed sea turtles and whales. In addition, we concluded that 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. We determined that the proposed action has the potential to result in the mortality of shortnose sturgeon and New York Bight Atlantic sturgeon from entrainment in a cutterhead dredge and by vessel strike from construction vessels. We also anticipate that the long-term operation of the NJWP will cause vessel strikes of Atlantic sturgeon New York Bight, Gulf of Maine, Chesapeake Bay, and South Atlantic DPSs as well as shortnose sturgeon. We expect cutterhead dredging to kill up to two (2) sturgeon. These may be two juvenile shortnose sturgeon, two juvenile New York Bight DPS Atlantic sturgeon, or one of each. In addition, 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 New York Bight DPS. Finally, we expect up to 39 lethal vessel strikes over the operational life of the NJWP[13]. Of these:

- Up to 4 shortnose sturgeon juveniles, adults, or mix of the two
- Up to 7 juvenile Atlantic sturgeon from New York Bight DPS
- Up to 16 adult Atlantic sturgeon from New York Bight DPS
- Up to 5 adult Atlantic sturgeon from Chesapeake Bay DPS
- Up to 5 adult Atlantic sturgeon from South Atlantic DPS
- Up to 2 adult Atlantic sturgeon from Gulf of Maine DPS

However, since the biological opinion was completed, we have received new information about reporting rates and reported mortalities in the Delaware River and Bay as well as proposed changes to the project. The USACE has requested that the consultation be reinitiated and we are waiting for an updated Biological Assessment with the new information.

6.3.5 Paulsboro Roll-on/Roll-off Berth

On July 19, 2022, we issued a biological opinion to the USACE for the development by the South Jersey Port Corporation (SJPC) of a Roll-on/Roll-off (RoRo) Berth in support of offshore wind projects in New Jersey and other U.S. East Coast states at the existing and under-development Paulsboro deep-water import-export marine terminal. The Paulsboro Marine Terminal is adjacent to the Delaware River and Mantua Creek in the Borough of Paulsboro, Gloucester County, New Jersey, along the east bank of the Delaware River at approximately RKM 145 (RM 90).

[13] In May 2022, we received guidance from the Northeast Fisheries Science Center that, although our general analytical approach for the vessel traffic analysis applied in prior consultations was sound, certain improvements should be made, including incorporating the findings of a recent study by Fox et al. (2020) into the vessel strike rate analysis used to inform the amount of anticipated take of Atlantic sturgeon. Fox et al. (2020) estimated Atlantic sturgeon carcass reporting rates for the Delaware River and Estuary. This study was specifically designed to estimate Atlantic sturgeon carcass reporting rates in the Delaware River while accounting for temporal and spatial differences.

Figure 13. Paulsboro Roll-on/Roll-off Berth

In the biological opinion, we concluded that the proposed action may adversely affect, but is not likely to jeopardize the continued existence of the shortnose sturgeon, the Gulf of Maine, New York Bight, Chesapeake Bay, and South Atlantic DPSs of Atlantic sturgeon. We concurred that the consequences of the construction and operations of the facility were not likely to adversely affect listed sea turtles and whales. In addition, we concluded that the proposed action may affect, but is not likely to adversely affect critical habitat designated for the New York Bight DPS of Atlantic sturgeon. We determined that the long-term operation of the Berth will cause vessel strikes of Atlantic sturgeon New York Bight, Gulf of Maine, Chesapeake Bay, and South Atlantic DPSs as well as shortnose sturgeon. We expect up to 8 lethal vessel strikes over the operational life of the Berth. Of these:

- Up to 1 shortnose sturgeon juveniles or adults
- Up to 1 juvenile Atlantic sturgeon from New York Bight DPS
- Up to 3 adult and/or subadult Atlantic sturgeon from New York Bight DPS
- Up to 1 adult or subadult Atlantic sturgeon from Chesapeake Bay DPS
- Up to 1 adult or subadult Atlantic sturgeon from South Atlantic DPS

- Up to 1 adult or subadult Atlantic sturgeon from Gulf of Maine DPS[14]

6.4 Federal Actions that have Undergone Informal Consultations

Several federally authorized private projects in the Delaware River have undergone informal consultation. These projects include dredging, construction (including pile driving), and vessel traffic associated with construction and operations of the new or modified port facilities discussed below. No interactions with ESA-listed sea turtles or sturgeon have been reported in association with any of these projects, nor has any take been authorized.

6.4.1 Consultations on Port and Terminal Constructions

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 USACE's 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

[14] Subsequent to completing the consultation, the Northeast Fisheries Science Center (NEFSC) completed a review of a sturgeon carcass database maintained by the New Jersey Fish and Wildlife (NJFW). Their review concluded that the reported carcasses included in the NJFW database were additional mortalities that were in addition to the observed mortalities reported in another database maintained by the Delaware Department of Natural Resources and Environmental Control (DNREC). Applying the reporting rates from NJFW and DNREC, as well as the updated guidance from the NEFSC on the mixed stock analysis rates, the updated incidental takes for Paulsboro are as follows: NYB 4; CB 2; SA 2; and 1 GOM. To ensure that this Opinion fully complies with the analytical requirements of the ESA, including the requirement to use the best available scientific information, we will apply the updated take estimates for Atlantic sturgeon derived from the NJFW and DNREC databases to the Environmental Baseline.

proposed project would not add vessels to the existing baseline as the need for transporting refinery products would occur irrespective of the proposed terminal.

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 10 kilometers (6.3 mi) upstream of the proposed Port. 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 pipeline, 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 any 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 to 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.

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 731.5 m (2,400 ft) 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.

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[15] class cargo vessels, which are typically 198 m (650 ft) long and 29 m (95 ft) wide. The fourth berth will be designated as a barge berth and is designed to accommodate a typical 122 m (400 ft) long by 30.5 m (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 percent 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, Atlantic sturgeon or sea turtles. 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

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

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.

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 Atmospheric Administration (NOAA), and USACE. We have conducted formal consultations with the USCG, the USN, EPA and NOAA on their vessel operations. In addition to operation of USACE vessels, we have consulted with the USACE to provide recommended permit restrictions for operations of contract or private vessels around whales. Through the Section 7 process, where applicable, we have and will continue to establish conservation measures for all these agency vessel operations to avoid adverse effects to listed species. Refer to the biological opinions for the USCG (September 15, 1995; July 22, 1996; and June 8, 1998) and the USN (May 15, 1997) for detail on the scope of vessel operations for these agencies and conservation measures being implemented as standard operating procedures. No interactions with sturgeon or sea turtles have been reported with any of the vessels considered in these biological opinions. The effects of vessels (private and commercial) in the action area are further considered in section 6.7.3.

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 ESA-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. 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 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[16]. 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 24 and Table 25). 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 24. 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.	Lethal Incidental mortality - 1 Adult/Sub-adult[17] - 1 Juvenile Direct mortality - 80 early life stages annually with no more than a total of 160	10 years, 02/27/2016 to 03/31/2027

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

[17] 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
				Non-lethal 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	
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) Incidental mortality - 1 adult/sub-adult[18] Non-lethal (annually) - 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)	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.		Lethal Incidental mortality - 1 adult (no more than 2 for 10 yr permit period) - 1 juvenile (no more than 2 for 10 yr permit period) Non-lethal - 10 adult - 65 juvenile	10 Years, 01/28/2021 to 01/31/2031

Table 25. 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	Lethal: Incidental mortality - 6 adult/juvenile Non-lethal: - 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.

[18] 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
			of Georgia and Florida		
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 - 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	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 Shortnose Sturgeons in the mid-Atlantic	- Marine waters between Virginia and New York. - Delaware Bay and Delaware River and estuary. - Hudson River and estuary	<u>Lethal (annually)</u> Direct mortality: - 150 early life stage from each of Delaware River and Hudson River Incidental mortality - 1 adult <u>Non-lethal (annually)</u> - 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)	<u>Lethal</u> 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) <u>Non-lethal</u> - 10 adult/subadult - 340 juvenile	10 Years, 01/28/2021 to 01/31/2031

6.5.1 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 (Table 26). We issued a biological opinion for the permit on June 19, 2020 (NMFS 2020). However, the action area for the consultation is outside of the action area for this consultation.

Table 26. Exelon Generating Company Section 10(a)(1)(B) permit.

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 2017b, 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 2017b). 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[19]. 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 an ASMFC Interstate Fisheries Management Plan (ISFMP) (including Amendment 1 in 2005 and Addendum 1 in 2010), but no specific management measures are required. Atlantic croaker are seasonally present in Delaware Bay; fishing occurs for this species in the Bay but not in the river.

[19] 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.

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 percent. 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-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 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; however, 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) 2020, 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.[20] 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

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

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 percent 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 to be exposed to the risk of interactions with this fishery; however, because increased controls have been placed on the shad fishery, impacts to shortnose and Atlantic sturgeon are likely less than they were in the past.

Striped Bass 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 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 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 m (<65.6 ft), with 90 percent occurring at depths of <30 m (<98.4 ft) (ASMFC 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 m (>210 ft) (ASMFC 2017a), 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 New Jersey 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 hosts multiple commercial terminals and docks for recreational vessels. Consequently, the navigation channel supports a large number of commercial and private vessels. A high volume of vessel traffic increases the risk of oil spills and leakage of hydrocarbon-based pollutants into the waters of the Delaware River and Bay (Delaware River and Bay Oil Spill Advisory Committee 2010), which may detrimentally impact Atlantic sturgeon critical habitat as well as individual sturgeon.

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 of 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 alters the pH of the water and 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 7 km (4.35 mi) upstream from the action area at Pedricktown, New Jersey. 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 (RM 63.5 and 68)) 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

Vessel traffic may affect ESA-listed sturgeon through generalized disturbance of essential life behaviors, injury/mortality due to collisions, and through the degradation of habitat (Brown and Murphy 2010, PIANC 2008, Stoschek *et al.* 2014). 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).

6.7.3 Vessel Activity within the Action Area

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 Project Area

The area between the Port and the Federal Navigation Channel does not currently have a maintained navigation channel and the majority of vessel disturbance is from vessel traffic to and from the Port of Wilmington, and the presence of recreational and fishing vessels. Thus, the river channel between the Federal Navigation Channel and the Port provides a foraging area and a passageway for spawning migrations where movement is uninterrupted by maintained vessel infrastructure.

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). The shallower draft recreational vessels commonly transect the project area; however, this activity is also highly seasonal. For example, almost no traffic occurs during December through March (U.S. Vessel Traffic https://livingatlas.arcgis.com/). 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 (328 ft) by 100 m (328 ft) cells is calculated using data from the automatic identification system (AIS) (Figure 14). 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 14). Based on the latest AIS vessel traffic layers created by MarineCadastre.gov in collaboration with the U.S. Coast Guard, over a 12-month period, an average count of 23 (min 1, max 81) tow or tug vessel transits occurred within a box approximating the project area. For all vessels (including passenger and fishing vessels) transecting or operating within the project area, an average of 26 vessels (min 1, max 93) transected a cell. Based on these data, a relatively low density of vessels operate within the project area. However, using the same data, an annual average of 3,136 vessels (min 93, max 6,050) occurred within each cell within the adjacent navigation channel. This data shows that vessel traffic in this reach of the river is concentrated to the Federal Navigation Channel with little traffic occurring within the Project Area (Figure 14).

Custom Area 19.18 nautical miles from ...

TRANSPORTATION AND INFRASTRUCTURE

Vessel Count

These data show the approximate number of vessels over 65 feet traversing the ocean within the U.S. Exclusive Economic Zone over a one-year period. This count is based on the latest automatic identification system (AIS) vessel traffic layers created by MarineCadastre.gov in collaboration with the U.S. Coast Guard. Understanding where vessels travel can help identify conflicts between various ocean uses. Vessel count can be highly variable across an area, so the average displayed may not be representative of the entire area. Turn on the data layer to understand the spatial distribution. Not shown here are any vessels classified as the following: military, not available, not identified, null, or other.

Type	Min	Mean	Max
All	1	25.63	93
Cargo	2	2.00	2
Fishing	1	1.00	1
Passenger			
Pleasure	1	1.00	1
Tanker			
Tugtow	1	22.38	81

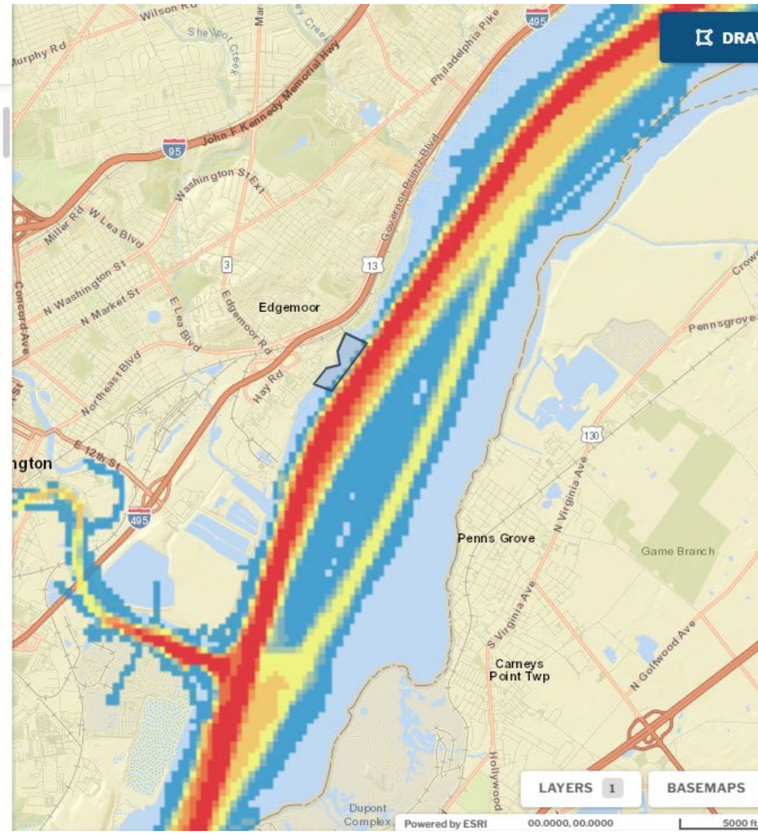

Figure 14. Vessel density in the area (outlined) where project vessels will operate during construction and operation of the proposed Edgemoor port. Vessel activity is represented as a number of vessels transecting each 100 x 100 square meter cell in a grid. Blue shades represent fewer vessels while shades of yellow and red represent areas of increased vessel density. The highest density of vessels occurs in the navigation channel.

Container vessels calling at the Port of Wilmington currently travel approximately 114 km (70.73 mi) upriver from the mouth of Delaware Bay to the mouth of Christina River where the vessels are turned with the assistance of tugs boats (typically two tugs) and then travel approximately 1-mile up Christina River, where they are maneuvered with tug assistance into a berth for loading or unloading. For the return trip to sea, the maneuvering is reversed, again with the assistance of tugs, and the vessels return to sea.

The tugs used to support the existing vessel traffic to the Port of Wilmington are typically based at the Port of Wilmington. They meet incoming vessels near the mouth of Christina River to help with the turning maneuver from the Delaware River Federal Navigation Channel into Christina River navigation channel and stay with the vessel until berthing is completed. The tugs help departing vessels leave the berth and turn from the Christina River navigation channel into the Delaware River Federal Navigation Channel. After the vessel completes the turn into the Delaware River navigation channel, the tugs typically return to berths at the Port of Wilmington. The tugs also assist with turning vessels 180 degrees in the Christina River either when they arrive at or when they depart from the Port of Wilmington.

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, Delaware represent one of the largest general cargo port complexes in the nation (Altiok *et al.* 2012).

The USACE Waterborne Commerce Statistics Center (WCSC) 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 WCSC 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 Opinion, the area of interest is the Philadelphia to the Sea Federal Navigation Channel in the Delaware River.

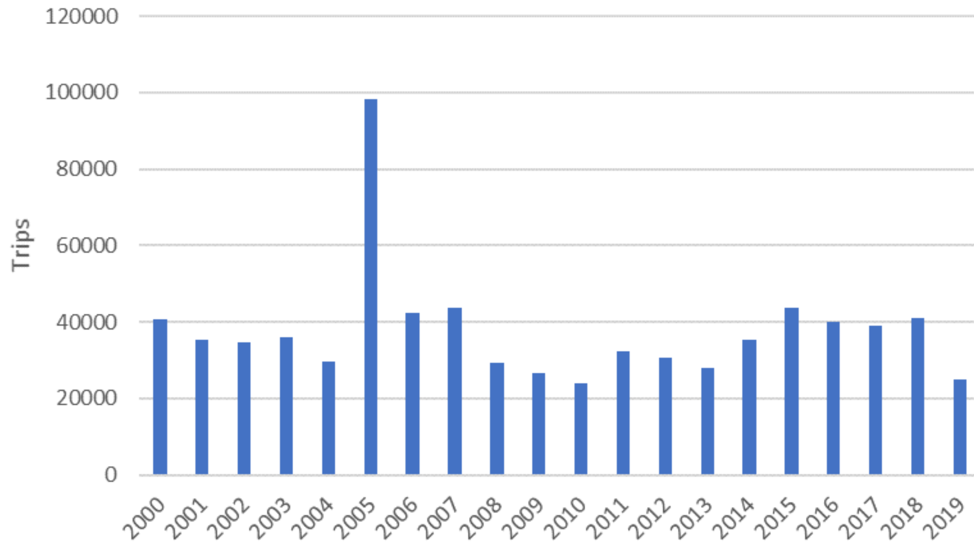

Figure 15. Annual number of trips by self-propelled vessels in the Trenton to the Sea Federal Navigation Channel.

The Waterborne Commerce data available to us includes data from 2000 to 2019. Vessel activity during this period in the Trenton to the Sea Federal Navigation Channel has varied with significant economic trends visible in the number of vessel trips (Figure 15). For this analysis, we used data from 2010 to 2019 to characterize the baseline annual vessel trips in the Philadelphia to the Sea Federal Navigation Channel (Figure 15). The annual number of trips for all vessels (self-propelled and non-self-propelled, all drafts) in the Federal Navigation Channel from Philadelphia to the sea ranged from 30,853 to 52,032 (median = 41,795) during the period from 2010 through 2019 (Table 26). 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.* 2012c, 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 are 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 27). 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.* 2012b, 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 7.6 m (25 ft) 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 downbound trips (median of 3,848, min=3,380; max=4,268) occurred by self-propelled vessels with a draft of 7.6 m (25 ft) or more (Table 27). Figure 16 shows the 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.* 2012a, Reine *et al.* 2014).

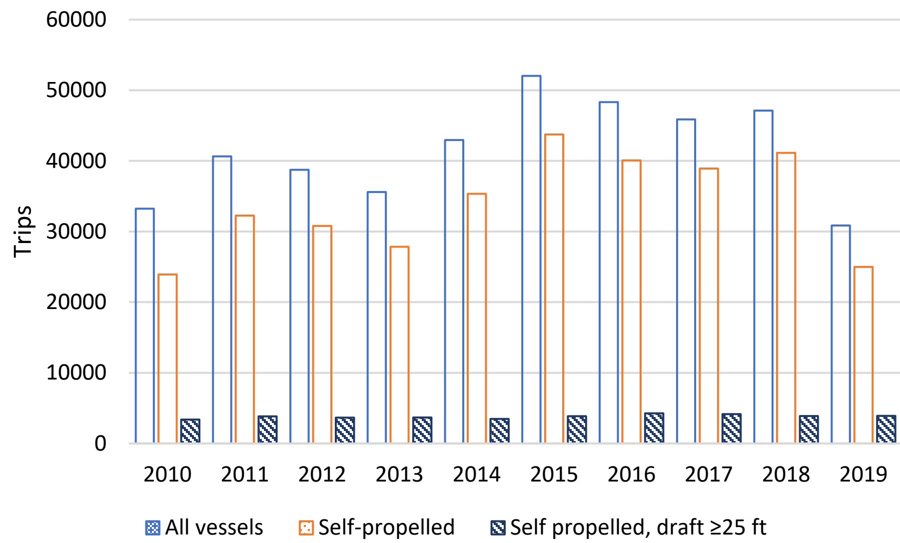

Figure 16. Annual number of Philadelphia to Sea vessel trips by vessel category (USACE Waterborne Commerce Data 2021)

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 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 27. Annual number of vessel trips, Philadelphia 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 28. Annual number of vessel trips, Philadelphia 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 29. Annual number of vessel trips, Philadelphia to the Sea for self-propelled vessels with a draft of 7.5 m (25 ft) 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**

6.7.4 Information on Sturgeon Mortality Resulting from Vessel Strike

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. The following section summarizes the best available information on the risk of vessel strike to shortnose and Atlantic sturgeon.

6.7.4.1 Available information and data

As detailed above, sturgeon vessel strike mortalities have been documented in the Delaware River and Bay and this is of concern as commercial traffic associated with the port system is high and may increase in the future. 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 were 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 percent of the mortalities reported being juveniles. The majority (71 percent) of sturgeon carcasses showed signs 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.* 2012a). 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).

<u>Delaware Department of Natural Resources and Environmental Control (DNREC)</u>

DNREC started a reporting program in 2005 where the public can report sturgeon carcasses they find in the Delaware River and Bay (https://dnrec.alpha.delaware.gov/fish-wildlife/fishing/sturgeon/). When possible, a biologist from the state or a sturgeon researcher will visit the site of the carcass to retrieve it, make a species identification, and collect data.

DNREC enters and maintains the sturgeon carcass data in an Excel spreadsheet. At the time of this consultation, data from 2005 to 2019 was available to us (data provided by Ian Park, DNREC, 2020).

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, DNREC, 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[21], public and state employees reported 242 sturgeon carcasses (excluding Atlantic sturgeon carcasses from an experimental study). Of these, 25 were reported from outside the Delaware River and Bay, leaving 217 carcasses observed within the Delaware River and Bay.

Of the 217 sturgeon carcasses reported within the Delaware River and Bay, 113 showed sign of interaction with boat propellers and 19 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 85 of the carcasses, either because they were too decomposed when examined by state biologists or proper pictures were not provided (for carcasses not physically examined by state biologist) to identify injuries. However, many of the decomposed carcasses had missing heads or consisted of only body parts suggesting that a large propeller mutilated them. When excluding mortalities where the cause of death was determined or suspected to have been caused by incidents (e.g., capture in dredge) other than vessel strike, the DNREC spreadsheet includes 198 carcasses from the Delaware River and Bay. Of these 198 vessel strike mortalities, 180 were Atlantic sturgeon, 13 were shortnose sturgeon, and five (5) were not determined to species (Table 29).

New Jersey Fish and Wildlife (NJFW)

The NJFW also has a public reporting program for sturgeon carcasses (https://www.nj.gov/dep/fgw/news/2013/sturgeon_reporting.htm), and they provided us with a spreadsheet that includes data on all carcasses reported along the shores in waters within the boundaries of the state of New Jersey (i.e., they do not track carcasses found outside of state boundaries) from 2013 to 2021. As with the DNREC data, the NJFW does not represent a scientific or dedicated survey. A 2022 review of the data by NOAA's Northeast Fisheries Science Center (NEFSC) found that none of the reported carcasses from NJFW were included in the DNREC data we previously considered. The review also indicates that the NJFW data constitutes the best available information in addition to the DNREC data, and that the carcasses reported to NJFW should be added to the total carcasses reported to DNREC when evaluating the risk of vessel strike in our analysis.

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

The NJFW spreadsheet contains 102 reported observations of sturgeon mortalities from New Jersey waters. In their review of the data, NEFSC determined that the location description for several reported carcasses reported in the Atlantic Ocean was likely wrong and subsequently corrected the location to either Delaware River or Delaware Bay. After the correction, the NJFW spreadsheet includes data for 37 sturgeon mortalities reported from the Delaware River and Delaware Bay (only within New Jersey state boundaries) between the years of 2013-2021.

NJFW staff did not determine the likely cause of death for the sturgeon reported to them, and the spreadsheet only provides comments for 21 of the 37 sturgeon carcasses reported from the Delaware River and Bay. Two Atlantic sturgeon were reported as being entrained in a hopper dredge operated by the USACE and are excluded for the purpose of this vessel strike mortality analysis. Of the remaining 19, two comments mention interaction with a propeller as the likely cause of injury; eight had descriptions of severed bodies and/or cuts consistent with an interaction with propellers; and the remaining nine comments did not include a description of injury. In all, excluding the two dredge mortalities, the NJFW spreadsheet includes data on 35 sturgeon carcasses from within the Delaware River and Bay. Of these 35, 23 were identified as Atlantic sturgeon, four (4) as shortnose sturgeon, and eight (8) were not identified to species (Table 30).

Table 30. Sturgeon carcass reports by data source. DNREC 2005-2019 records and NJFW 2013 to 2022 records. The table shows the number of all sturgeon carcasses reported, the number of all sturgeon carcasses reported within the Delaware River and Bay, and the number of carcasses reported within the Delaware River and Bay by species.

SOURCE	REPORTED - TOTAL	DELWARE RIVER & BAY (R & B): ALL	DELWARE R&B: VESSEL & UNKNOWN	ATLANTIC: R & B VESSEL & UNKNOWN	SHORTNOSE: R & B VESSEL & UNKNOWN	UNKNOWN: R &B VESSEL & UNKNOWN
DNREC	242	217	198	180	13	5
NJFW	102	37	35	23	4	8
BOTH	**344**	**254**	**233**	**203**	**17**	**13**

The DNREC and NJFW spreadsheets include a total of 233 vessel strikes and unknown cause of death records of sturgeon carcasses in the Delaware River and Bay of which 220 were identified either as Atlantic sturgeon (203) or shortnose sturgeon (17) (Table 30).

6.7.4.2 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, the actual number of sturgeon mortalities is probably greater than the 233 reported above. For past biological opinions we have used a study of sturgeon carcass observations on the James River (Virginia) by Balazik *et al.* (2012b) that found monitoring in the James River documented about one-third of all vessel strike mortalities. However, the purpose of the study was to determine the likelihood of researchers finding carcasses during carcass surveys rather than opportunistic reporting rates. The Delaware State University in partnership with the USFWS and DNREC conducted a study to estimate opportunistic reporting rates of carcasses in the Delaware River and Bay. The estimated reporting rates varied from 2.0 (spring 2018) to 12.5 (summer and fall 2018) percent with a reporting rate of 4.76 percent when they combined the data for all seasons over the two years (2018 and 2019) of the study.

Because there is substantial uncertainty regarding the precise rate of interactions, carcass observations, as well as other factors such as seasonality, annual fluctuations in number and type of vessels, distribution and abundance of sturgeon, we asked the Northeast Fisheries Science Center (NEFSC) to review our analytical approach to determine mortality rates associated with vessel strikes and the best available data. In May 2022, after careful review of the vessel strike take calculations used in past Opinions developed by staff at the Greater Atlantic Regional Fisheries Office, Protected Resources Division, the NEFSC provided guidance that, although our general analytical approach for vessel traffic analysis was sound, certain improvements should be made, including incorporating the findings in Fox *et al.* (2020) into the vessel strike rate analysis used to inform the amount of anticipated take of Atlantic sturgeon.

This guidance was based on the fact that Balazik *et al.* (2012c) did not design their study to estimate a reporting rate. The Balazik study occurred during a short time period (approximately 4 weeks) in a single year, the sample size was small (16 deployments with some fish deployed more than once), and the researchers were actively searching for the carcasses. By actively searching for the carcasses, the study design biased the reporting rate higher than would likely be experienced in a natural setting. Acknowledging these facts should not take away from the quality science performed by Balazik *et al.* (2012b), and are identified only to illustrate that the use of a carcass reporting rate from this study likely underestimated the number of unobserved mortalities in the Delaware River as it was not intended to estimate the efficiency of public reporting of sturgeon carcasses. However, as previously it was the only available peer-reviewed estimate, it was the best available scientific data.

In comparison, the Fox *et al.* (2020) was specifically designed to estimate Atlantic sturgeon carcass reporting rates in the Delaware River. For the study, Fox *et al.* (2020) deployed a total of 168 carcasses seasonally over two years, providing a greater sample size and temporal distribution than Balazik *et al.* (2012c). Additionally, Fox *et al*. (2020) relied on multiple sources of reporting and was not solely based on researchers actively searching for the carcasses.

Although the Fox *et al.* (2020) study provides reporting rates by season, the NEFSC recommended using the reporting rate combined across both years and all seasons because this number leverages the strength of reports from the entire time series (8 out of 168). The new rate of 4.76 percent is substantially smaller than the roughly one third percentage rate used in prior biological opinions, but, as noted above, this new rate is the best available information. This rate will be applied in this Opinion.

Based on the conclusion that (Fox *et al.* 2020) represents the best available information for carcass reporting rates on the Delaware River and Bay, we used the combined reporting rate of 4.76 percent and the number of observed (i.e. reported) carcasses to estimate the actual (reported and non-reported) number of mortalities. Table 31 and Table 32 shows the number of reported Atlantic sturgeon and shortnose sturgeon, respectively, and the estimated number of mortalities when applying the reporting rate from Fox *et al.* (2020) to estimate the actual number of sturgeon mortalities.

Table 31. Number of reported and adjusted Atlantic sturgeon carcasses within the Delaware River and Bay. Shaded area shows when data from DNREC and NJFW reports overlap. Adjusted numbers are calculated by dividing observed (reported) numbers by the report.

YEAR	DNREC	NJFW	BOTH	ADJUSTED
2005	7	N/A	7	147
2006	11	N/A	11	231
2007	6	N/A	6	126
2008	10	N/A	10	210
2009	5	N/A	5	105
2010	13	N/A	13	273
2011	19	N/A	19	399
2012	16	N/A	16	336
2013	22	0	22	462
2014	12	0	12	252
2015	9	1	10	210
2016	19	2	21	441
2017	9	2	11	231
2018	9	8	17	357
2019	13	6	19	399
2020	N/A	2	2	42
2021	N/A	2	2	42
All Years	180	23	203	4,265
2013-2019	93	19	112	2,353

Table 32. Number or reported and adjusted shortnose sturgeon carcasses within the Delaware River and Bay. Shaded area shows years when data from DNREC and NJFW overlap. Adjusted numbers are calculated by dividing observed (reported) numbers by the reporting rate of 0.0476.

YEAR	DNREC	NJFW	BOTH	ADJUSTED
2005	0	N/A	0	-
2006	0	N/A	0	-
2007	0	N/A	0	-
2008	0	N/A	0	-
2009	0	N/A	0	-
2010	0	N/A	0	-
2011	3	N/A	3	63
2012	2	N/A	2	42
2013	1	1	2	42
2014	0	0	0	-
2015	3	2	5	105
2016	2	1	3	63
2017	0	0	0	-

2018	0	0	0	0
2019	2	0	2	42
2020	N/A	0	0	0
2021	N/A	0	0	0
All Years	13	4	17	357
2013-2019	8	4	12	252

6.7.4.3 Atlantic sturgeon vessel mortalities

For purposes of this Opinion, we assume that unknown 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 anthropogenic mortalities from other causes are reported as such (e.g., capture in dredge). However, some anthropogenic mortalities may not be reported (e.g., sturgeon caught in fishing nets). With the exception of one sturgeon noted as caught in gillnet and one as predated, none of the comments on individual records in the data indicate that something other than a vessel strike was the cause of death (e.g., presence of gillnet scars or entangled in fishing gear).

For the years 2005-2021, the two datasets include 203 reports of Atlantic sturgeon carcasses within the Delaware River and Bay for which the cause of death was unknown or identified as vessel strike. Using the 4.76 percent reporting rate from Fox *et al.* (2020), we estimate that the number of observed mortalities represents 4,265 actual Atlantic sturgeon mortalities within the river and bay.

Since the DNREC and the NJFW data overlap for the years 2013 to 2019, we use this period to calculate average annual mortality. Combined, for the years 2013-2019, the two data sets include 112 records from the Delaware River and Bay of Atlantic sturgeon with vessel strike or unknown as the cause of mortality. The number of Atlantic sturgeon mortalities considered as vessel strikes ranged from three (2015) to 14 (2013) with an average of 7.9 reported sturgeon mortalities per year. Using the 4.76 percent reporting rate gives an adjusted average of 165 vessel strikes per year. Assuming Atlantic sturgeon with unknown cause of death were in fact vessel strike mortalities, the adjusted number of Atlantic sturgeon carcasses reported each year ranged from 210 (2015) to 462 (2013) with a median of 357 and an average of 336 mortalities per year.

<u>Seasonal and Life Stage Distribution of Mortalities</u>

The majority of Atlantic sturgeon mortalities in the Delaware River and Delaware Bay were reported during spring and early summer (Table 35). Fifty-eight (58) percent of the Atlantic sturgeon vessel strike and unknown mortalities were reported during May and June. Ninety (90) percent 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.

The NEFSC reviewed sturgeon length data in the DNREC spreadsheet to determine the life stage of Atlantic sturgeon based on reported length measurements.

Table 33. Guidance for the assignment of life stages to Atlantic sturgeon carcasses.

Stage	Minimum TL (cm)	Maximum TL (cm)
Adult	≥150	
Subadult	≥76	<150
Juvenile		<76

The DNREC spreadsheet has life stages assigned to 132 of the carcasses found in the Delaware River and Bay between 2005 and 2019. Upon review, NEFSC deferred to the biologists that had examined the carcasses to determine life stage and assumed that all carcasses assigned as adult Atlantic sturgeon in the spreadsheet were correct. However, with the exception of three carcasses reported as subadults, the DNREC spreadsheet did not distinguish between juvenile (pre-migration to the ocean) and subadult Atlantic sturgeon. A closer review of reported total length or size of carcass segments suggest that many of those denoted as juvenile in the DNREC spreadsheet were likely subadult Atlantic sturgeon. Also, several records in the spreadsheet reported TL or other length measurements but did not assign life stage to them. Using the length guidance in Table 33, NEFSC used best professional judgment to assign each fish a juvenile or subadult life stage based on reported measurements and descriptions of each carcass in the comment section. In all, NEFSC assigned life stages to 153 of the Atlantic sturgeon carcasses found in the river (Table 34). The DNREC spreadsheet did not include life stage or length measurements that NEFSC could evaluate for the remaining 26 Atlantic sturgeon reported from the Delaware River and Bay.

Table 34. Number and percentage of Atlatnic stugeon adult, subadult, juvenile, and unknown life stages.

Life Stage	Number	Percent
Adult	96	53.33%
Subadult	33	18.33%
Juvenile	24	13.33%
Unknown	26	15.00%
All	**179**	**100.00%**

Including only those reported as vessel mortalities, the majority (73 percent) of adult carcasses were reported during May and June while juvenile vessel strike mortalities were more evenly distributed across months (Table 35). The number of reported adult carcasses has the same distribution (70 percent reported in May and June) when both vessel strike mortalities and unknown mortalities are included (Table 36). Substantially fewer subadult than adult carcasses are reported from the Delaware River and Bay. However, while subadult carcass reports also peak in May, reports of carcasses continue to be relatively high through October (Table 36). The highest number (16) of reported carcasses (vessel strike and undetermined mortalities) of undetermined life stages was reported in May with three carcasses reported in each of June and July. These 22 carcasses constitute 85 percent of the Atlantic sturgeon carcasses of unknown life stage (Table 36). Most of the carcasses of unknown life stage were from May indicating that these individuals may be subadult or adult fish. In contrast to adults, juveniles were reported throughout the year though with somewhat higher numbers in June and July.

Since some carcasses were mutilated and size was estimated from remains, it is possible that some of the sturgeon reported as adults were sub-adults and vice versa. In addition, the relatively higher percentage of sturgeon reported between spring and fall may be a result of less public activity along the river during winter. Still, despite seasonal bias in reporting rates and possible mischaracterization of life stage, the results agree with findings by others that the majority of 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.* 2012c, Brown and Murphy 2010, Fisher 2011).

Table 35. Number of Atlantic sturgeon vessel strike mortalities within the Delaware River and Bay each month over the years 2005 to 2019. Based on data provided by DNREC. A = adult, SA = subadult, J = juvenile, Ukn = unknown life stage.

Month	A#	A%	SA#	SA%	J#	J%	Unk#	Unk%	All#	All%
January	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*
February	0	*0.00*	0	*0.00*	1	*7.69*	0	*0.00*	1	*0.97*
March	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*
April	2	*2.99*	1	*5.26*	0	*0.00*	0	*0.00*	3	*2.91*
May	29	*43.28*	3	*15.79*	0	*0.00*	4	*100.00*	36	*34.95*
June	20	*29.85*	3	*15.79*	3	*23.08*	0	*0.00*	26	*25.24*
July	4	*5.97*	4	*21.05*	3	*23.08*	0	*0.00*	11	*10.68*
August	4	*5.97*	3	*15.79*	2	*15.38*	0	*0.00*	9	*8.74*
September	2	*2.99*	3	*15.79*	0	*0.00*	0	*0.00*	5	*4.85*
October	5	*7.46*	1	*5.26*	3	*23.08*	0	*0.00*	9	*8.74*
November	1	*1.49*	1	*5.26*	0	*0.00*	0	*0.00*	2	*1.94*
December	0	*0.00*	0	*0.00*	1	*7.69*	0	*0.00*	1	*0.97*
All Months	**67**	***100.00***	**19**	***100.00***	**13**	***100.00***	**4**	***100.00***	**103**	***100.00***

Table 36. Number of both Atlantic sturgeon vessel strike and unknown mortalities within the Delaware River and Bay each month over the years 2005 to 2019. Based on data provided by DNREC. A = adult, SA = subadult, J = juvenile, Ukn = unknown life stage.

Month	A	A%	SA	SA%	J	J%	Unk	Ukn%	All	All%
January	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*	0	*0.00*
February	1	*1.04*	0	*0.00*	1	*3.45*	0	*0.00*	2	*1.11*
March	0	*0.00*	0	*0.00*	2	*6.90*	0	*0.00*	2	*1.11*
April	3	*3.13*	1	*3.45*	2	*6.90*	2	*7.69*	8	*4.44*
May	38	*39.58*	7	*24.14*	2	*6.90*	16	*61.54*	63	*35.00*
June	28	*29.17*	4	*13.79*	7	*24.14*	3	*11.54*	42	*23.33*
July	5	*5.21*	5	*17.24*	5	*17.24*	3	*11.54*	18	*10.00*
August	6	*6.25*	3	*10.34*	3	*10.34*	0	*0.00*	12	*6.67*
September	5	*5.21*	4	*13.79*	1	*3.45*	1	*3.85*	11	*6.11*

October	8	*8.33*	4	*13.79*	4	*13.79*	1	*3.85*	17	*9.44*
November	2	*2.08*	1	*3.45*	1	*3.45*	0	*0.00*	4	*2.22*
December	0	*0.00*		*0.00*	1	*3.45*	0	*0.00*	1	*0.56*
All Months	**96**	***100.00***	**29**	***100.00***	**29**	***100.00***	**26**	***100.00***	**180**	***100.00***

Baseline Vessel Strike Risk

As described in section 6.3.2.1, DNREC maintains records of observed sturgeon mortalities within the Delaware River and Delaware Bay. Since 2012, public outreach and social media campaigns have improved public reporting of sturgeon carcasses (DNREC 2016) and 2019 is the most recent year of complete carcass data available to us. In addition, the NJFW provided us with data on reported sturgeon carcasses spanning the years from 2013 through 2021. These data represent the best available information for calculating sturgeon mortalities per vessel trip.

We use the combined DNREC and NJFW 2013 to 2019 data together with the WCSC vessel trip data during the same period to calculate the risk of a vessel striking a sturgeon within the Delaware River and Bay. We calculated the risk of a vessel strike by dividing the number of suspected vessel mortalities by the number of vessel trips during the same time period. This provides us with an estimate of vessel strike mortalities per vessel trip based on observed mortalities (M_o). However, since we expect that the number of observed mortalities is a fraction of actual mortalities within the Delaware River and Bay, we use the estimated reporting rate (4.76 percent) by Fox *et al.* (2020) to adjust the risk of vessel strikes by dividing M_o by the 4.76 percent reporting rate to produce an adjusted vessel strike risk (M_a).

As mentioned above, for the years 2013-2019, the DNREC and NJFW data sets include 112 records from the Delaware River and Bay of Atlantic sturgeon with vessel strike or unknown as the cause of mortality. For purposes of this biological opinion, we conservatively assumed that unknown 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 anthropogenic mortalities from other causes are reported as such (e.g., capture in dredge). However, some anthropogenic mortalities may not be reported (e.g., sturgeon caught in fishing nets). Thus, assuming that all the reported mortalities with unknown cause of death were vessel strikes, the 112 reported Atlantic sturgeon mortalities in the Delaware River and Bay were caused by vessel strikes over the 7-year period (2013 through 2019), with an average of 16 reported vessel strike mortalities per year.

We obtained the number of vessel trips between Trenton and the mouth of the Delaware Bay from Waterborne Commerce data for the years 2013 through 2019. The WCSC 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 and 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 (<6.1 m (<20 ft)) 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 10.7 m (35-ft) recreational vessel traveling at 33 knots on the Hudson River was reported to have struck and killed a 1.7 m (5.5-ft) Atlantic sturgeon (NYSDEC sturgeon mortality database (9-15-14)).

Since sturgeon remain close to the bottom most of the time (Balazik *et al.* 2012a, 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 the observation of many severed sturgeon carcasses suggest 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.

6.7.4.3.1 Baseline vessel risk for Atlantic sturgeon

Table 37. Vessel trip and carcass report statistics.

	Min	Max	Mean	Median	Total
Atlantic Sturgeon Mortalities	10	22	15.6	16	109
Vessel Trips	24,992	43,754	36,013	38,925	252,091

The number of vessel trips between Trenton and the mouth of the Delaware Bay during the period from 2012 to 2019 was 252,091. Given this scenario, we estimate the number of sturgeon killed per vessel trip by dividing the estimated number of Atlantic sturgeon vessel mortalities (109) by the number of vessel trips (252,091) over the same period (Table 37). Thus, using the observed data, each vessel trip (M_o) killed 0.000432 sturgeon.

Given the known difficulties in observing deceased fish in a large, dynamic environment like the Delaware River and Estuary, it is necessary to account for unobserved mortalities. In this Opinion, this is referred to as the adjusted annual mortality rate and is calculated by dividing the observed annual mortality rate (M_o) by an externally derived carcass reporting rate (Fox *et al.* 2020). This is represented by:

$$M_a = \frac{M_o}{R}$$

where M_o is the observed annual mortality rate and R is the Carcass Reporting Rate.

Using the carcass reporting rate calculated by Fox *et al.* (2020), we can calculate an actual or adjusted mortality rate by dividing M_o by 0.0476 to get a M_a of 0.0091 (i.e., we estimate that on average 0.0091 sturgeon are killed per vessel trip). This equates to one Atlantic sturgeon killed on average for every 110 vessel trips. The calculations show that the probability of a vessel strike is low for any one vessel traveling on the river or in the bay. However, as noted above, the Delaware River supports a number of major port complexes with many related vessel trips occurring per year. Therefore, the high level of vessel movements overlapping with the presence of Atlantic sturgeon aggregation sites, spawning migrations, and spawning areas, causes a high risk of vessel strikes within the action area.

6.7.4.4 Shortnose sturgeon vessel mortalities

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. The fish was not necropsied; however, 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 percent) were adults, three (23 percent) were juveniles, and no life stage was reported for seven (54 percent) of the carcasses.

The NJFW data (2013 to 2022) includes four shortnose sturgeon that were reported from the Delaware River and Bay. The information provided to us by NJFW did not include any description of injuries and the cause of death is unknown.

Of the 17 reported carcasses (DNREC and NJFW combined), 12 were reported between 2013 and 2019. If we assume that mortalities of unknown cause were vessel strike mortalities and that only 4.76 percent of carcasses are reported, then there were approximately 252 shortnose sturgeon vessel strike mortalities in the Delaware River during that seven-year period. With 252,091 vessel trips during the same period, approximately 0.001 shortnose sturgeon are killed per vessel trip. This equates to one shortnose sturgeon vessel strike mortality occur for every 1,000 vessel trips.

The low number of shortnose sturgeon carcasses reported from the Delaware River basin may be related to a several factors: little overlap between vessel activity and shortnose sturgeon distribution; low numbers of large fish present in areas with high vessel activity; fewer observed and reported remains due to their smaller size relative to Atlantic sturgeon; a combination of these factors; or other unknown factors. However, we do not have data to correct for these uncertainties.

6.7.5 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 13.7 m (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 0.6 m (2 ft) of draft clearance. Most of the largest tankers make their port calls before the Walt Whitman Bridge in Philadelphia. Given the size of the vessels and the proximity of the propeller to the bottom of the channel, there is a constant disturbance regime (increased turbidity and TSS) throughout the navigation channel. 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 and critical habitat. Climate change is relevant to the *Status of the Species*, *Environmental Baseline*, *Consequences 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 was 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 (1.05-2.03 ft) under the low GHG emissions scenario, 0.44-0.76 m (1.4-2.5 ft) under the intermediate GHG emissions scenario, and 0.63-1.01 m (2.07-3.3 ft) 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 in 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 2017). 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 (82.4°F) 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 1°C 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 have 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 by 1°C.

The action area does not include spawning grounds for shortnose and Atlantic sturgeon; however, sturgeon 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, Hare *et al.* (2016a) 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.* 2016b). 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 percent (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 best 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**.** As the Applicant has indicated that they entered into a 50-year Concession Agreement with GT USA for the operation of the Port, we consider here the likely consequences of climate change 50 years from when the Port becomes operational.

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 (PBF 1). 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 (PBF 2). 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 (PBFs 1-4). 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 (PBF 4). 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 (PBF 4).

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/RM 133-148) of the Delaware River more than 90 river kilometers (>56 mi) 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/RM 77.7) to Trenton, New Jersey, (~RKM 214/RM 133) 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 2070, but modeling conducted by Collier (2011) suggests that by 2100, some areas within the range where spawning is thought to occur (RKM 125-212/RM 77.7-132) 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 (RM 67-76) due to changes in sea level rise in 2100 (i.e., shift to RKM 122-137/RM 76-85 based on a 1986 EPA report for the Delaware Estuary) and under extreme historic drought (i.e., restricted to RKM 125, 130 and 153 (RM 77.7, 81 and 95) 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/RM 77.7-133) is at greater risk from encroaching salt water as some of the best potential rearing habitat occur at the downstream end of that range (i.e., Marcus Hook Bar area below Little Tinicum Island). Above Little Tinicum Island (RKM 142/RM 88), 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 (86°F) in the south (see Damon-Randall *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C (82.4°F). 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 (80.6-84.2°F) and >30°C (86°F) 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 will 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 (82.4°F). 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 (51.8-80.6°F) from April through November, with temperatures lower than 11°C (51.8°F) 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 (82.4°F)) 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 and critical habitat, 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 50-year life span of the Port.

As mentioned earlier, the overall vulnerability of Atlantic sturgeon to climate change has been found to be very high (Hare *et al.* 2016a). Moberg and DeLucia (2016) recommended the following water quality standards to support successful recruitment of Atlantic sturgeon in the Delaware River: instantaneous DO ≥ 5.0 mg/L; temperature < 28°C (82.4°F); 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 2017) 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 (77°F). In temperatures greater than 26°C (78.8°F), DO levels greater than 4.3 mg/L are needed to protect survival and growth. Temperatures of 13 to 26°C (55.4-78.8°F) 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. Therefore, 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 a combination of vibratory and cushioned impact pile driving equipment from two to three crane barges with tug support in-water to install approximately 4,500 20-in concrete-filled steel piles for construction of the wharf structure. Plumb vertical piles will be spaced roughly on 3 m (10-ft) centers and batter (angled) piles will be placed in one row on 1.5 m (5-ft) centers for the wharf support. Two rows of piles intended to support gantry crane rails will be placed on 1.5 m (5-ft) centers beneath the wharf. Batter piles will be installed along the riverfront side of the wharf. The total number of piles also accounts for possible termination piles at the ends of the wharf. The piles will be coated with an epoxy coating for corrosion protection.

A sheet pile retaining wall, consisting of PZ steel sheets, will be constructed along the landward edge of the wharf. The sheets will be interlocking to create a full coverage steel faced wall with a depth of 40.6 cm (16 in). The sheets will be installed by vibration in 3 to 4.6 m (10 to 15 ft) of water (post-dredging depths) and will be installed from the landside of the site from the existing grade, the majority of which is above the low tide line.

Driving of piles generates sound pressure waves that travel 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 consequences 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 consequences of exposure to underwater noise; and the established thresholds and criteria to consider when assessing impacts of underwater noise. We also present the results of the Fish and Hydroacoustics Working Group' review of hydroacoustic pressure levels and consequences on fish to help inform the analysis[22]. We then present empirical data and modeling provided to establish the noise associated with pile installation and consider the consequences 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

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

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 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 Effects

There is limited data from other projects to demonstrate the circumstances under which immediate mortality occurs: mortality appears to occur when fish are close (within 0.9 m to 9.1 m (3 ft 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 2.4 m (8 ft) in diameter, whereas Ruggerone *et al.* (2008) found no mortality to caged yearling coho salmon (*Oncorhynchus kisutch*) placed as close as 0.6 m (2 ft) from a 0.5 m (1.5 ft) diameter pile and exposed to over 1,600 strikes. As noted above, the data indicates that species have different tolerances to noise and may exhibit different responses to the same noise source.

Potential physiological consequences are highly diverse. Sound exposure that may result in mortality-inducing physiological consequences could in one species result in physiological effects that would have no effect on fish survival in another. Potential consequences range from very small ruptures of capillaries in fins (which are not likely to have any consequences on survival) to severe hemorrhaging of major organ systems such as the liver, kidney, or brain

(Stephenson *et al.* 2010). Other potential consequences 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.

Consequences 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 those 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 consequences of pile driving on fish (Molnar *et al.* 2020). The criteria were developed for the acoustic levels at which physiological consequences to fish could be expected. It should be noted that these are the onset of physiological consequences (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 the 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 consequences 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 consequences. 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 consequences to sturgeon are likely to occur. Thus, for the purposes of this Opinion, we consider the potential for physiological consequences upon exposure to 206dB re 1 μPa peak and 187 dB re 1 μPa^2-s cSEL. It is important to note that physiological consequences 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 Consequences

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

For purposes of assessing behavioral consequences 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 consequences. That is not to say that exposure to noise levels of 150 dB re 1 μPa RMS will always result in behavioral modifications or that any behavioral modifications will rise to the level of take (i.e., harm or harassment) but that there is the potential, upon exposure to noise at this level, to experience some behavioral response. Behavioral responses could range from a temporary startle to avoidance of an ensonified area.

As hearing generalists, sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005), which does not propagate as far from the sound source as does pressure. However, a clear threshold for particle motion was not provided in the Lovell study. In addition, flanking[23] of the sounds through the substrate may result in higher levels of particle motion at greater distances than would be expected from the non-flanking sounds. Unfortunately, data on particle motion from pile driving is not available at this time, and we 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 consequences could be expected. With

[23] Flanking sound (or flanking noise) is sound that transmits between spaces indirectly, going over or around, rather than directly through the main separating element.

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 in air (approx. 4900 ft./s vs. 1100 ft./s), and it attenuates much less rapidly than in air. As a result of the greater speed, the wavelength of a particular sound frequency is about 4.5 times longer in water than in air (Rogers and Cox 1988; Bass and Clarke 2003).

Pile installation for the Port is expected to take approximately 800 days to complete, with no in-water work between March 15 and July 15. Based on this schedule, 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, 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.

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[24]. 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

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

Acoustic Tool uses 5dB/10m attenuation rate, 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 (summarized in Tables below).

To attenuate noise levels from pile driving by impact hammer, a cushion block consisting of multiple layers of plywood approximately 30.5 cm (12 in) thick will be used. WSDOT (2006) demonstrated that wood cushion blocks can reduce underwater sound levels by 11 to 26 dB compared to an unattenuated impact hammer if functioning properly. However, Buehler *et al.* (2015) recommended that a specific sound level reduction credit not be taken for the use of cushion blocks because of the limited nature of the WSDOT study, their ability to attenuate noise was highly variable, and because they can splinter or break. Because the consequences of a wood cushion cap 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 of 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 38 and Table 39 provide estimated sound levels and distance from piles where injury and behavioral effects would occur for the 20-in diameter concrete filled steel piles and sheet piles, respectively. For the steel sheet piles, we use sound monitoring for standard 24-in size sheet piles as proxy projects to estimate driving of sheet piles for the bulkhead.

Table 38. Estimated intensity and extent of underwater noise for a 20-inch concrete filled steel pipe 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 (in)**	**Pile Type**	**Hammer Type**	**Attenuation rate (dB/10m)**
A	Stockton, CA	3-4	20	Steel Pipe	Vibratory	3
B	Stockton, CA	3-4	20	Steel Pipe	Cushioned Impact	3

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	20-inch Steel Pipe	198	177	166
B	20-inch Steel Pipe	197	176	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	NA	63.3	100.0
B	NA	60.0	96.7

a. Proxy Project

Proxy	Project Location	Water Depth (m)	Pile Size (in)	Pile Type	Hammer Type	Attenuation rate (dB/10m)
A	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	175	160	160

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	NA	30.0	30.0

Table 39. Estimated intensity and extent of underwater noise for 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.

Based on the data above, driving (with the proposed cushion) steel pipe piles will not result in peak sound levels above 206 dB. Thus, there is no potential for physiological consequences due to exposure to peak noise levels during construction of the wharf structure. Based on sound measured at a 10 m (33 ft) distance from the pile (with the proposed vibratory hammer), peak sound levels will also not reach injury levels for 24-in steel sheet piles (Table 39c).

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.[25] 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

[25] 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.

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 sSELwith an 11dB attenuation from use of cushion block, we estimated distances of sSEL of 150 dB during impact driving. The distance for the proxy projects was 60 m (197 ft) for the 20-in steel pipe piles. Sturgeon that remain within a distance up to 60 m (197 ft) of the steel pipe piles during construction of the wharf structure will be exposed to injurious levels of noise during installation of the piles. During installation of the sheet pile, sturgeon that remain within a distance up to 30 m (98 ft) of a 24-in sheet pile driven with a vibratory 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 percent 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 relation 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 96.7 m (317 ft) from the piles being driven. 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 would be for the 20-in steel pipe piles. Assuming pile driving times of approximately fifteen minutes; a sturgeon would need to swim at least 60 m (197 ft) before the fifteen minute pile driving time was completed, requiring a swim speed of approximately 0.07 m (0.23 ft) per second to leave the ensonified area. Deslauriers and Kieffer (2012b) measured sustained swimming speed (swimming against a current for 200 minutes) for young-of-the-year shortnose sturgeon to 18 cm/s (0.18 m/s). Further, shortnose sturgeon young-of-the-year could sustain swimming at velocities of 0.35 m/s for up to 30 to 50 minutes depending on water temperature (Deslauriers and Kieffer 2012a).

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

The cSEL 187 dB re 1μPa^2-s area never occupies the entire width of the river; therefore, 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 for long enough to accumulate enough energy to be injured. Further, the use of a reduced energy "soft start"[26] 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 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 consequences (e.g., low DO, high temperature, unsuitable salinity); thus, it is reasonable to anticipate that sturgeon will also 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 the sheetpile while full strength pile driving was ongoing. Because of soft start techniques, cushion blocks, and vibratory hammers 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 long enough to cause injury.

8.1.6 Summary of physiological consequences

As described above, we do not expect driving of 20-in steel pipe piles to produce injurious peak sound levels (≥206 dBpeak). Thus, construction of the wharf will not expose sturgeon to injurious peak dB levels. Similarly, we do not expect that the driving of sheetpiles with a vibratory hammer will result in injurious peak sound levels. Exposures 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 analysis, 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 that 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 shortsnose 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.

[26] 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.

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 installation technique, the 150 dB re 1 µPa RMS isopleth (radius) would extend from 96.7 to 100 m (317 to 328 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 sustained speed of 0.18 m (0.6 ft) per second (mps), all sturgeon would be able to swim out of the area where noise is 150 dB re 1uPa RMS within 9 minutes. Thus, we expect any disruption to normal behaviors to last for no longer than 9 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 9 minutes, and generally much shorter) disruption of foraging, resting or migrating will have any impact on the health of an individual sturgeon. In addition, because we expect these movements to occur at normal sustained 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 2.4 km (1.5 mi) wide from the Delaware bank to the New Jersey bank. The wharf structure will extend 34.1 m (112 ft) from shore. Thus, the behavioral disturbance at the ensonified area will extend a maximum of 134.1 m (440 ft) into the channel. At all times, there will be at least 2,266 m (~7,434 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 the worst case scenario behaviorally, where sturgeon need to avoid areas with underwater noise greater than 150 dB re 1 µPa during active pile driving, 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 Port construction activities are located approximately 150 m (492 ft) from the Federal Navigation Channel. With noise levels not expected to extend into the channel, 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 applicant proposes to deepen portions of the Delaware River adjacent to the Federal Navigation Channel to create a primary access channel that will serve the proposed berth construction at the Edgemoor Site. Dredging for the Edgemoor Container Port Project is expected to take up to 3 years to complete, with no in-water work between March 15 and July 15. The applicant plans to dredge approximately 3.3 million cy of material from approximately 87 acres within the Delaware River.

Dredging will be performed with one cutterhead dredge supported by two tugs, a crew boat, and a hydrographic survey vessel, over three dredge events. The initial event, to extend over a period of 105 dredge days, is proposed to occur between July and September. The second event, to extend over a period of 60 dredge days is proposed to occur between January and February. The third event, to extend over a period of 60 dredge days is proposed to occur between July and September (Table 2).

8.2.1 Hydraulic Cutterhead Dredge

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

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.

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 that 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. Monitoring of dredge disposal areas used for deepening of the Delaware River with a cutterhead dredge has occurred. Dredging in Reach C occurred 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 have been conducted to understand the behaviors of Atlantic sturgeon and shortnose sturgeon. The USACE worked with sturgeon researchers 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 behaviors were 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 2091) opposite the Federal 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) concluded that sturgeon do not modify their behavior in presence of active cutterhead dredges based on studies they carried out in the James River (Virginia). Reine *et al.* (2014) implanted five subadult Atlantic sturgeon (TL = 77.5- 100 cm) with both active and passive transmitters, released the fish in the immediate vicinity of the dredge, and tracked them continuously for several days. 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 able to and freely swim past the operating dredge during their estuarine migrations and no incidents of entrainment occurred (Balazik *et al.* 2020).

Additional scientific studies have been undertaken to understand the ability of sturgeon to avoid being entrained in the intake of cutterhead dredges. Hoover *et al.* (2011) demonstrated the swimming performance of juvenile lake sturgeon and pallid sturgeon (12 – 17.3 cm FL) in laboratory evaluations. The authors compared swimming behaviors and abilities in water velocities ranging from 10 to 90 cm/second (0.33-3.0 fps). Based on the known intake velocities of several sizes of cutterhead dredges. At distances more than 1.5 m (5 ft) from the dredges, water velocities were negligible (10 cm/s). The authors concluded that in order for a sturgeon to be entrained in a dredge, the fish would need to be almost on top of the drag head and be unaffected by associated disturbance (e.g., turbidity and noise). The authors also conclude that juvenile sturgeon are only at risk of entrainment in a cutterhead dredge if they are in close proximity, less than one meter (3.3 ft), to the cutterhead.

Boysen and Hoover (2009) assessed the probability of entrainment of juvenile white sturgeon by evaluating swimming performance of young of the year fish (8-10 cm (3.1-4 in) TL). The authors determined that within 1.0 m (3.3 ft) 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 in) would be 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 (5-6.5 ft) of the dredge head; beyond that distance, velocities decrease to less than 0.3 mps (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 (3.3 ft) from the dredge head and that the velocity reduces to approximately 40cm/s at a distance of 1.5 m (5 ft), 25cm/s at a distance of 2 m (6.6 ft) and less than 10cm/s at a distance of 3 m (9.8 ft). Clarke also reports on swim tunnel performance tests conducted on juvenile and subadult Atlantic, white and lake sturgeon. He concludes that there is a risk of sturgeon entrainment only within one meter of a cutterhead dredge head with a 36-in pipe diameter and suction of 4.6 mps.

8.2.2 Predicted Entrainment of sturgeon in a cutterhead dredge

Adult and sub-adult sturgeon are at low risk of entrainment in cutterhead dredges because a dredge head needs to be within one meter of them in order to potentially affect their ability to swim away. As studies in the Delaware and James Rivers have shown, sturgeon do not typically react to cutterhead dredge presence. Juvenile and adult shortnose sturgeon, and juvenile Atlantic sturgeon occur in the general vicinity of the Port year-round. Adult Atlantic sturgeon may be present in the area during the first proposed construction dredging event (July to October) and the third (August to September), but are unlikely to be present during the second event, which will be in mid-winter. Due to their larger size and seasonal occurrence, for the purposes of this Opinion, we do not expect that adult Atlantic sturgeon will be entrained.

During dredging at the Edgemoor site, the smaller size of juveniles makes them more likely than large adult sturgeon to be at risk of entrainment. However, there are several factors that may increase the risk of entrainment in the upper Delaware River that are not present where cutterhead dredging will occur for this action. The season (entrainment during winter months), the behavior of the fish (overwintering in dense aggregations where they rest on the bottom and exhibit little movement and may be slow to respond to stimuli such as an oncoming dredge), and the location (fairly narrow and constricted portion of the Delaware River), may have all played a role in limiting the ability of sturgeon to avoid the oncoming dredge. The dredging at the Port is within a reach of the Delaware River that is 2.4 km (1.5 mi) wide (the upper Delaware at Newbold Island is approximately 400 m wide), and cutterhead dredging will not occur where fish may be in dense aggregations (overwintering is not known to occur in the dredging footprint, but they do overwinter in the lower tidal river in the vicinity of Marcus Hook and Chester, Pennsylvania, which is approximately 11.3 km (7 mi) upstream). Moreover, at the Edgmoor site, we anticipate that only one of the three proposed dredge cycles will occur in the winter. Although we expect that sturgeon will be present, tracking studies in the James and Delaware Rivers demonstrate that sturgeon are not attracted to the dredging equipment they also show dredging operations do not affect sturgeon behavior[27]. Therefore, it is likely that nearly all sturgeon in the action area will never encounter the dredge as they would not occur within 1 m (3.3 ft) of the dredge and movement is not confined to a narrow stretch of the river. Information from the tracking studies in the James and Delaware River supports this risk assessment.

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. However, there were no reported takes of juvenile, subadult or adult sturgeon from the use of a cutterhead dredge for maintenance dredging of the 45-ft Philadelphia to the Sea Navigation Channel during the period from March 2010 through June 2019, which illustrates the rarity of these interactions. Deepening occurred in Reach C, Reach B and Reach A. Dredging in Reach C occurred from March – September 2010 with 3,594,963 cy of material removed with a cutterhead dredge. Dredging in Reach B, which overlaps with the Federal Navigation Channel portion of the action area in this Opinion, occurred in November and December 2011, with 1,100,000 cy of material removed with a cutterhead dredge. Dredging in Reach A occurred from September – February 2013 with the removal of approximately 1.2 million cy of material with a cutterhead dredge. In all cases, the dredge disposal area was inspected daily for the presence of sturgeon. We received no reports that sturgeon were detected. Based on the available information presented here, entrainment in a cutterhead dredge is likely to be rare, and would only occur if a juvenile

[27] 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.

sturgeon is within one meter of the dredge head. However, because we know that entrainment is possible, we expect that during construction, some entrainment with a cutterhead dredge will occur.

Previous Biological Opinions issued by us for projects with cutterhead dredges removing large quantities of material in areas where multiple life stages of sturgeon are present have quantified the mortality of juvenile sturgeon. In 2019, the Biological Opinion for the James River Federal Navigation Project, estimated take based on similar factors as noted above, and concluded that no more than one sub-adult or juvenile Atlantic sturgeon would be entrained per 1.5 million cy (no more than 1 per year) by the cutterhead dredge used for maintenance dredging in the action area. In 2022, our Biological Opinion for the New Jersey Wind Port, concluded that the cutterhead dredging of 4,290,000 cy of material in an 82 acre area on the Delaware River would kill two sturgeon – either a juvenile or adult shortnose sturgeon, juvenile Atlantic sturgeon, or one of each.

Our analysis for this Opinion similarly reflects an understanding of the likely risks to sturgeon from the ongoing use of cutterhead dredges within this reach of the Delaware River. Based on the predicted rarity of the entrainment event, the presence of sturgeon year round in the vicinity of the Port, the duration of each cycle, and the quantity dredged per event, we expect that no more than one sturgeon (either Atlantic or shortnose) will be entrained per dredge cycle (no more than 1 per cycle). Due to the force of the suction, travel through up to several miles of pipe, and any residency period in the disposal area, all entrained sturgeon are expected to be killed. The shortnose sturgeon would be either juvenile or adult (section 6 of this Opinion). 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 16 to March 14 the following year). Because of their smaller size, any Atlantic sturgeon entrained in the cutterhead would be juvenile fish. Since 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.

8.2.3 Summary of consequences

Cutterhead dredging will kill one sturgeon per dredge cycle. The killed fish will be either shortnose sturgeon or Atlantic sturgeon.

- Shortnose sturgeon mortalities will be either juvenile(s) or adult(s).
- Atlantic sturgeon mortalities will be juvenile fish. All New York Bight DPS.

8.3 Interaction with Suspended Sediment

Dredging suspend 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).

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 dissolved oxygen levels. For all fish species in which consequences 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 taken into consideration as it may influence turbidity and re-suspended sediment at a 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 Consequences Thresholds for Total Suspended Sediment (TSS) and Turbidity

Literature reviews of the consequences of suspended sediment on fish show that consequences varies greatly among species and suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993, Kjelland *et al.* 2015, Wilber and Clarke 2001). Burton (1993) evaluated 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 effects ranged from "no effect" when exposed to 14,000 mg/L for a duration of three days for two species to the lowest observed concentration that caused mortality at 580 mg/L after one day of exposure for Atlantic silverside. The concentration of suspended sediment is not the only factor determining 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 regard sublethal and lethal consequences 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 dissolved oxygen falls below certain levels. Jenkins *et al*. (1993) observed that younger shortnose sturgeon experienced high levels of mortality at low dissolved oxygen levels while older individuals tolerated those reduced levels for short time periods. Tolerances may decline if chronic exposure to low dissolved oxygen levels occurs. 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 effects. During times when early life stages could be present in an action area, it is recommended that they 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 affect Atlantic sturgeon or shortnose sturgeon foraging. Sturgeon typically occur in turbid waters and Atlantic sturgeon and shortnose sturgeon forage by rooting along the bottom with their snout in search for benthic prey that they grasp with their protruberant mouth (Gilbert 1983, Kynard *et al.* 2016). During foraging, they use their barbels as sensory organs to detect prey (Hilton *et al.* 2016, Kynard *et al.* 2016). Both species also actively forage during night (Dadswell *et al.* 1984). Based on foraging method, tolerance to high turbidity and foraging during night it is unlikely that visual detection of prey is of major importance for Atlantic sturgeon and shortnose sturgeon foraging success. Elevated TSS levels resulting in physiological consequences may elicit avoidance behavior and movement away from turbidity plumes. Studies on another 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 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 resuspended during lateral swinging of the cutterhead as the dredge progresses forward. Modeling results of cutterhead dredging indicated that TSS concentrations above background levels would be present throughout the bottom 1.8 m (6 ft) of the water column for a distance of approximately 305 m (1,000 ft) (ACOE 1983). Elevated suspended sediment levels are expected to be present only within a 300-500 m (984.3 to 1,640.4 ft) 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).

8.3.2.2 Pile driving

The installation of piles will disturb bottom sediments and may cause a temporary increase in suspended sediment in the action area. Using available information collected from a project in the Hudson River, we expect pile driving activities to produce total suspended sediment (TSS) concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 91 m (300 ft) of the pile being driven (FHWA 2012). Using a vibratory hammer to extract piles 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 consequences 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 Erosion and stormwater runoff

The release of stormwater during construction of the Port site may temporarily increase suspended sediment concentration, thus elevating turbidity in the receiving waterbody. Erosion and stormwater runoff associated with adjacent upland activities during construction of the proposed Port 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 in the effluent will be trapped or be allowed to settle out of suspension.

8.3.2.4 Compensatory Mitigation

Two mitigation plans are proposed to offset the identified impacts to fish habitat from the project, which primarily result from the filling of the space landward of the sheet pile retention wall and shading associated with the proposed wharf. The compensatory mitigation plans include several upland and in-water elements. At the first site, fish passage is to be provided to 12.5 acres of upstream habitat through the construction of a rock ramp fishway on the downstream face of the Dam 2. Dam 2 is located above the fall line in Brandywine Creek and approximately 7.6 km (4.7 mi) upstream of the Delaware River. This portion of Brandywine Creek has not been identified as habitat for endangered or threatened species and is not part of the designated Delaware River critical habitat for Atlantic sturgeon. The second project involves the construction of intertidal habitat at Fox Point State Park at RKM 119.7 (RM 74.4) of the Delaware River to create a functioning intertidal habitat and wetlands. To restore tidal flow, fills that have been placed will be removed. The project will include removal of a portion of a revetment placed to construct the current shoreline and removal of material, believed to be primarily slag and dredge tailings, to restore the natural river substrate.

The placement and removal of structures for compensatory mitigation could result in temporary, localized increases in suspended sediment at the mitigation site. Suspended sediment concentrations and sediment plumes associated with the construction of the rock fishway and revetment removal would be lower than those associated with dredging and pile driving. As a proxy to evaluate potential sediment concentrations and turbidity plume, 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 (i.e., eggs and yolk-sac larvae) are not likely to be present at or adjacent to the Port 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 Port 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, pile driving, and compensatory mitigation projects will occur between July 16 and March 14 and, 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, these activities may expose all these life stages to elevated sediment concentration and turbidity.

8.3.4 Response to exposure

Juvenile and adult sturgeon are frequently found in turbid water and would be capable of avoiding any sediment plume by swimming higher in the water column. Laboratory studies (Niklitschek 2001, Secor and Niklitschek 2002) have demonstrated shortnose sturgeon are able to actively avoid areas with unfavorable water quality conditions and that they will seek out more favorable conditions when available. Additionally, the highest TSS levels expected for any of the dredging is up to 550 mg/L (cutterhead dredging), which is below those shown to have lethal and sublethal consequences on estuarine fish (typically up to 1,000.0 mg/L; see summary of scientific literature in Burton 1993, and Wilber and Clarke 2001).

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 are below those shown to have adverse consequences on fish, so 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 at the Port site that may cause avoidance will be the sediment plumes generated by pile driving and hydraulic dredging, with radii of 91 m (298.5 ft) and 500 m (1,640.4 ft), respectively. Construction at the two mitigation sites may also generate elevated levels of suspended sediments; however, sturgeon are not likely to be present in Brandywine Creek and excavation of the revetment openings at Fox Point Park will be limited to periods when the areas are exposed by tidal conditions. Given the river width in the vicinity of the Port (approximately 2.4 km (1.5 mi)), the plumes would affect 3.8 to 20.8 percent 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. Thus, any avoidance of the plume will not hinder upstream or downstream movements of sturgeon.

Avoidance of turbidity plumes may cause adult Atlantic sturgeon to move into the shipping channel and increase their exposure to vessel strike during the spawning migration; however, dredging will not occur during Atlantic sturgeon spawning migrations.

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

8.3.5 Consequences of Interaction with Suspended Sediment

Construction of the Port may expose older juveniles and adults of both shortnose sturgeon 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. Thus, no injury or mortality will occur. Sturgeon may avoid turbidity plumes, but this will not be a barrier to migration. Sturgeon may make small evasive movements to avoid turbidity plumes, but these small adjustments are unlikely to affect growth, survival, or fecundity. Early life stages are not expected to be present within the portion of the action area where dredging and elevated turbidity could occur. 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.

Soft substrate supports 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, surveys by Kreeger *et al*. (2010) showed abundance benthic resources throughout the river in the general vicinity of the Edgemoor site, which would provide foraging areas for sturgeon. Further, acoustic surveys of the riverbed show bottom substrate within the Dredging Area consists of fine-grained sediments (silt/clay/sand).

8.4.1.1 Dredging

Dredging for the Edgemoor Container Port Project is expected to take up to 3 years to complete, with no in-water work between March 15 and July 15. The total dredge footprint occupies approximately 87 acres of the existing riverbed. The harbor of the Port is to be dredged to a flat bottom corresponding with a maintained depth of -13.7 m (-45 ft) MLW consistent with the maintained depths of the Federal Navigation Channel and is proposed to cover an area of 64.5 acres. The transitions into the harbor from the upriver and downriver subaqueous slopes are to be dredged to a 6 horizontal to 1 vertical slope, and a 3 horizontal to 1 vertical slope along the shore from the base of the sheet pile wall to the front of the wharf. Dredging will temporarily remove all benthic invertebrates within the dredge footprint. We expect that this activity 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 may affect composition and density of the invertebrate fauna.

8.4.1.2 Vessel Traffic

Vessels maneuvering in shallow waters can result in major erosion of the riverbed and suspension of sediment (Breedveld *et al.* 2018, 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.* 2018, 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.* 2018, 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.* 2018, 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). We expect the propeller jets from 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 Dynamic Positioning (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 Port will have large sized propellers, and have a draft clearance of less than 3 m (9.8 ft) in the access channel and the docking site. Therefore, we expect the operation of the Port 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 strikes 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 young-of-the-year Atlantic sturgeon occur within the action area. Both Atlantic sturgeon and shortnose sturgeon commonly use depths of 6 m (19.7 ft) or deeper in the Delaware River. The area between the Philadelphia to the Sea Navigation Channel and the Port generally ranges from 0-13.7 m (0-45 ft). Thus, the depth at the Port site is within the depth range where sturgeon are commonly found.

Sturgeon will be exposed to the temporary loss and permanent reductions of benthic prey within the project area. The bank-to-bank area of the river from RKM 78 to 118 (RM 48.5 to 73.3) equals approximately 34,240 acres. The action area within the Federal Navigation Channel between RKM 118 and 78 (RM 73.3 to 48.5) is 2,230 acres; however, it is uncertain what percentage of the channel supports benthic prey because maintenance dredging and regular vessel disturbance can create a suboptimal environment. The acreage of habitat within the project area is 935.5 acres. Therefore, we estimate the total action area (Channel and Port) between RKM 78 and 118 (RM 48.5 to 73.3) to be 3,165.5 acres. Dredging during construction and bottom disturbance by vessels during operation will result in the loss and reduction of prey within 87-acres. Based on this, the proposed project will expose Atlantic sturgeon and shortnose sturgeon to a reduction of forage within 73 percent (2,230 acres + 87acres) of the 3,165.5 acre action area between RKM 78 and118 (RM 71.3 and 73.3) and within 6.7 percent of the river between RKM 78 and 118 (RM 48.5 to 73.3).

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 polyhaline Delaware Bay and marine waters. The proposed project will result in removal of 87 acres of forage within the dredge footprint for up to 3 years and reduce the density of forage during the operational years of the Port. 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 73 percent of bottom habitat 87 acres + 2,230 acres/ 3,165.5 acres). The action area still contains approximately 848.5 acres of soft bottom substrate. Further, the Federal Navigation Channel plus the dredge footprint constitutes only a small percentage of the river between RKM 78 and 118 (RM 48.5 and 73.3). Within this entire reach, the proposed project will expose sturgeon to a 6.7 percent reduction in forage habitat. Younger Atlantic sturgeon and shortnose sturgeon move seasonally between the lower estuary at the mouth of the river and the Port area. We assume they use this whole area for foraging. Thus, the reduction in forage within the dredge footprint and the Federal Navigation Channel from the scour from vessel traffic represents a small percentage of foraging habitat used by the sturgeon.

8.4.4 Consequences of Habitat Modification and Loss of Forage

When added to baseline bottom disturbances, the proposed project will affect a relatively small 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 available bottom habitat, and the temporary loss of benthic invertebrates within the 87-acre dredge footprint and the routes construction vessels will use to access the Port, including the Federal Navigation Channel is small relative to the amount of soft bottom habitat present in the Delaware River estuary and within the action area. Therefore, we do not expect the proposed project to limit forage for juvenile Atlantic sturgeon or shortnose sturgeon. 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 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 and vessel use of the Port access channel and turning basin is too small to be meaningfully measured, detected, or evaluated. Therefore, consequences are insignificant.

8.5 Vessel Strike

In this section of the 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 Port will cause an increase in vessels operating within the Delaware River and the Delaware Bay. Vessels supporting construction and dredging will operate within the Philadelphia to the Sea Navigation Channels for up to 3 years. 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 50-year operational lifespan of the Port.

An operating vessel can cause injury or death to a sturgeon when the hull or propeller strikes the sturgeon, or the sturgeon becomes 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.* 2012a, Brown and Murphy 2010; also, see discussion in previous sections of this Opinion). Direct observations of vessel 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.* 2012b).

The construction and operation of the proposed Port is expected to increase vessel traffic at the 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 Port on ESA-listed sturgeon.

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., not moving away or trying to avoid interaction) 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. In other words, 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), and, 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 either Atlantic sturgeon 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 the current 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. 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 traveled (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 (1.6 ft) in diameter, towboats and tugs commonly have propellers between 2-3 m (6.5-9.8 ft) in diameter, and tankers and bulk carrier vessels with a 12 m (40 ft) draft may have propellers that are 7-8 m (23-26 ft) 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 (8.9 ft) pushing three barges side by side (total width of 32 m (105 ft)) in 4.3 to 12 m (14 to 40 ft) deep water and a speed (relative to water) of 2 m/s (3.9 knots) had an inflow zone of about 25 m (82 ft) on either side of the center line. Thus, water within a 50 m (164 ft) 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 (32.1 ft) or greater were not drawn into the 2.4-m (7.9 ft) diameter propeller (for a towboat with a 2.7 m (8.9 ft) draft) while water at depths of 5.6 m (18 ft) 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 (19.7 ft) 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 sometimes 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; 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 (9 ft) 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 (≥5 in) 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 propeller's revolutions 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 percent for a 12.5 cm (4.9 in) fish to 5 percent for a 35 cm (13.8 in) long fish, and from 50 percent for a 72 cm (28.3 in) long fish to 80 percent for a 90 cm (35.4 in) long fish. However, Killgore *et al.* (2011) did not find that the number of fish entrained by the propeller was dependent on RPM even though the percentage of fish killed increased with increasing 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 volumes of water, and have a shallow draft. Consequently, they are extremely unlikely to entrain a larger juvenile, 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). Further, observations of total mutilations such as completely or partially cut through gives an indication of the size of the propeller. 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 (8.2 ft), a draft of up to 2.7 m (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 – including its 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 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 Activity during Construction

During construction, tugboats, crew vessels, and dredge vessels will operate in the channel between the Port site and the Philadelphia to the Sea Navigation Channel. Further, crew boats, a survey vessel, and some of the tugs will operate out of the existing Port of Wilmington Autoberth, located along the right downriver side of the Federal Navigation Channel in the Delaware River, approximately 4.3 km (2.6 mi) downriver of the Edgemoor site. Therefore, Port construction could result in vessel strikes that injure or kill sturgeon. If the construction of the Port results in a substantial increase in sturgeon exposure to vessels over baseline conditions, then we can expect an increase in vessel strike mortalities.

This section considers the effects to sturgeon from vessel traffic associated with the construction of the Port over the approximate 3-year construction period. First, we evaluated the factors determining the risk of vessel strikes by vessels. We then use the calculated number of sturgeon mortalities relative to vessel activity in the action area from section 6.7.3 to calculate an estimate of sturgeon killed per vessel trip. This is the calculated baseline mortality rate. We then use this baseline mortality rate to calculate how many sturgeon we anticipate will be killed by construction-related vessel activity (i.e., vessel trips by project vessels during construction at the Port).

8.5.2.1 Construction Vessel Activity

The channel between the Port and the Federal Navigation Channel is currently free of maintained vessel infrastructure and the only vessel disturbance is traffic to the Port of Wilmington and the presence of occasional recreational vessels. As described in the baseline section, an average count of 23 tow or tug vessels transited 100 m (328 ft) by 100 m (328 ft) cells along the shore outside of the navigation channel. When all vessel types were included, the project area had an average of 26 vessels transecting a cell (section 6.7.3.1).

Water depth within the Project Area varies but is generally 6 m (20 ft) 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 8.5.1) 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.

Pile driving will be performed from two, possibly three barges, each supported by one tug and one crew boat. Barges used for pile driving are expected to stay on site for the duration of each pile driving season (170 days) and each barge will be supported by one tug and one crew boat. The crew boat and tug might travel daily to and from the site (Biological Assessment). Dredging will be performed over the course of three dredging events. Each of the dredge events will include one cutterhead dredge supported by two tugs, a crew boat, and a hydrographic survey vessel. The crew boats, survey vessel, and the tugs are anticipated to operate out of the existing Port of Wilmington, located approximately 4.3 km (2.6 mi) downriver of the Edgemoor site. The tugs and crew boats may travel back and forth to the Port of Wilmington each day while dredging and pile driving is in progress (Biological Assessment). Table 40 shows anticipated vessel activity calculated based on the information provided in the project description in the BA. All construction activities will occur between July 16 and March 14 the following year. Therefore, we expect all vessel trips associated with pile driving and dredging to occur during this period.

Table 40. Anticipated vessel activity.

Activity	Vessel	Number	Daily Trips	Days	Total Trips
Pile Driving	3 Tug, 3 crew	6	2	340	4,080
Dredging	2 Tugs, crew	3	2	225	1,350
Dredging	survey vessel	1	2	6	12
All	All				5,442

The construction will increase vessel activity with 5,442 vessel trips between the Edgemoor port site and the Port of Wilmington over a three-year period. Currently, there are very few vessels transecting the project area (see section 6 of this Opinion), and the construction of the Port (as well as its operation) will result in a substantial increase in vessel activity.

8.5.2.2 Risk Calculations

There are neither quantitative scientific surveys regarding vessel strike mortalities nor an annual index survey that provides a time series of the relative number of vessel strikes per year. This complicates any evaluation of the relationship between vessel densities and sturgeon mortalities. The biological assessment assumes that the increase in vessel traffic above baseline resulting from the construction at the Port 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 consider construction-related vessel trips of self-propelled vessels only to calculate risk of vessel strike as tugs transport non-self-propelled vessels (e.g., barges) and we expect interaction with a propeller to be the main source of mortality. We expect that the data for waterborne commerce vessel trips adequately represent the potential for sturgeon to be exposed to vessel interactions within the Delaware River. As we discussed in section 6.3, this is a reasonable approximation, as the Waterborne Commerce data used includes 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 reported sturgeon mortalities. Thus, even though the data does not account for the 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.

Last, our analysis must account for the fact that most sturgeon mortalities are likely never found and/or reported. Consistent with (Fox *et al.* 2020), here we use a reporting rate of 0.0476 to adjust the observed reporting rate as described in the baseline section of this biological opinion. We also note that Fox *et al.* (2020) had zero back-reports of carcasses placed in the river during their study of carcass reporting rates and that an unknown number of sturgeon carcasses may never end up on the shoreline since some carcasses are likely to sink and remain on the bottom. Therefore, because there is no basis we can rely on to calculate, carcasses that sink before ending up on a shoreline are not included in the calculation of reporting rates.

8.5.2.3 Atlantic Sturgeon

Juvenile, and subadult Atlantic sturgeon may occur in the action area throughout the year and adults are known to occur there seasonally. Therefore, the vessel traffic related to construction at the Port could interact with these life stages of Atlantic sturgeon and result in vessel strike mortalities.

8.5.2.3.1 Exposure

Atlantic sturgeon temporal and spatial distribution within the action area is described in section 6.2.2. The in-water construction window (July 16 to March 14) overlaps with juvenile Atlantic sturgeon presence in the Delaware River. It also overlaps with the presence of adult and subadult Atlantic sturgeon, which may be present in the upper tidal river from April through September. Thus, the operation of construction-related vessels overlaps in space and time with the distribution of juvenile, subadult, and adult Atlantic sturgeon.

During early spring, mature adults migrate through the bay mouth during the spawning migration. Additionally, both subadults and adults move through the mouth during seasonal migrations to and from areas of residency within the Delaware Bay (Breece *et al.* 2018). However, during the same time period, non-spawning Atlantic sturgeon may remain in the Bay. Kuntz (2021) found a large number of Atlantic sturgeon concentrated from late spring through the fall in two locations in the lower Delaware Bay. We expect that the spawning Atlantic sturgeon will move in a relatively straight line during spawning migration through the Delaware Bay. This path largely corresponds 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 the 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 season, they may use the Philadelphia to the Sea Navigation Channel for up and downstream spawning migration. Atlantic sturgeon swim closer to the surface during migration and during other directed movements (e.g., foraging or avoidance) (Balazik *et al.* 2012b, Fisher 2011, Reine *et al.* 2014). Consequently, Atlantic sturgeon are likely to occur at a depth that overlaps with the depth of the propeller of medium draft vessels (e.g., tugs) as well as deep draft vessels (e.g., cargo vessels) during periods when active movements such as spawning migration and/or seasonal movements between habitats occur.

Based on the above, there is a high likelihood that the construction at the Port will expose juvenile, subadult, and adult Atlantic sturgeon to moving vessels and their propellers; however, since no construction activities will occur between March 15 and July 15, vessel traffic in support of construction activities does not overlap in time with the majority of the adult sturgeon migration period. This exposure would not occur but for the proposed action.

8.5.2.3.2 Species' Response

Vessel traffic, consisting of commercial cargo ships, tankers, and tug boats have been identified as a significant source of Atlantic sturgeon mortality in the Delaware and James 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- and medium-draft commercial vessels with large propellers that draw large volumes of water, thus entraining sturgeon.

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 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.

8.5.2.3.3 Risk

Given the substantial increase in vessel traffic over baseline conditions, the more than 117.8 km (73.2 mi) that vessels will travel between the mouth of the Delaware Bay and the Edgemoor Port that is used as a migratory corridor, the size of the vessels and their propellers, the limited clearance between vessel hulls and the riverbed when operating outside of the navigation channel, 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.

8.5.2.3.4 Calculation of Take

In our previous Opinion, we estimated that one Atlantic sturgeon vessel mortality may occur for every 898 vessel trips during project construction. Thus, over the up to three years proposed for construction, we expected construction vessels to kill up to six (6) Atlantic sturgeon. We expected the sturgeon either to be Atlantic sturgeon juveniles (because of the relatively higher density) or New York Bight DPS adults (exposure prior to and post spawning migration). Any juveniles were expected to be the offspring of spawning in the Delaware River and, therefore, of the New York Bight DPS.

We calculated that the adjusted annual baseline mortality rate (or Atlantic sturgeon killed per vessel trip on average) is 0.0091[28]. This also equates to one vessel strike per approximately 110 vessel trips. The USACE estimates that the construction at the port will add up to 5,442 new vessel trips in the Delaware River (i.e., vessel trips that would not occur but for the proposed marine terminal) over the 3 years of construction. The additional 5,442 vessel trips will result in the vessel strike mortality of 49.5 Atlantic sturgeon (i.e., 5,442 vessel trips * 0.0091 killed per trip) during the 3 years of construction. Given that a vessel strike cannot kill a fraction of a fish, we anticipate that vessel traffic associated with construction at the Port will kill 50 Atlantic sturgeon over 3 years.

Here, we consider several factors relevant to assessing the risk of vessel strike of Atlantic sturgeon by construction support vessels. Vessels supporting pile driving and dredging activities will travel along a stretch of the river that supports rearing of juvenile sturgeon, and high densities of sturgeon may be present in this reach relative to other reaches of the river that were included when calculating the risk of vessel strike mortality (see section 6). The majority of time when foraging, juvenile sturgeon are expected to remain at or near the river bottom. The Federal Navigation Channel is approximately 14 m (46 ft) deep and the zone of influence of a tug may extend to a depth of 9 m (29.5 ft). Thus, demersal juveniles in the 14 m (46 ft) deep navigation channel may not 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 sturgeon migrating upstream past the Port site to upstream spawning areas are expected to move higher in the water column and well within the depth of drafts of tugboats (Balazik *et al.* 2012a, Fisher 2011, Reine *et al.* 2014). Therefore, we anticipate that the highest risk for a tug, crew, or survey vessel to interact with sturgeon will occur during the spawning migration when adults swim higher in the water column. Since no construction activities will occur between March 15 and July 15, vessel traffic in support of construction activities does not overlap in time with the majority of the sturgeon migration period. Further, a substantially higher number (72.75 percent) of Atlantic sturgeon carcasses are reported during the months of May through July (Table 35 and Table 36), supporting the assumption that the highest risk of vessel strike occurs outside of the work window. Still, sturgeon have been reported during late July through November (Table 36).

Based on the above, we believe that the risk of construction vessels interacting with sturgeon is relatively low and that the number of sturgeon mortalities from vessel strikes should reflect the period when vessel activity occurs. Thus, we believe that the construction vessel activity will result in only 27.25 percent or 14 (13.6 rounded up) of the 50 Atlantic sturgeon vessel strike mortalities that we calculated above. We expect that all Atlantic sturgeon killed will be of the

[28] Mo = 109/252,091 = 0.000432, Ma = 0.000432/0.0476 = 0.0091. For description of calculations, see section 6.3.2.3

New York Bight DPS because vessels are most likely to interact with juveniles rearing in the reach, pre and post migration adults.

8.5.2.4 Shortnose sturgeon

Juvenile and adult shortnose sturgeon may occur in the action area throughout the year. Therefore, the vessel traffic associated with the construction activities at the Port could interact with these life stages of shortnose sturgeon and result in vessel strike mortalities.

8.5.2.4.1 Exposure

Shortnose sturgeon distribution within the action area is described in section 6.2.1. The in-water construction window (July 16 to March 14) overlaps with adult and juvenile shortnose sturgeon presence in the Delaware River. During construction, tugboats, crew vessels, and dredge vessels will operate in the channel between the Port site and the Philadelphia to the Sea Navigation Channel. Further, crew boats, a survey vessel, and some of the tugs will operate out of the existing Port of Wilmington Autoberth, located along the right downriver side of the Federal Navigation Channel in the Delaware River, approximately 4.3 km (2.6 mi) downriver of the Edgemoor site. Both juvenile and adult shortnose sturgeon occur from Trenton, New Jersey, downstream to the mouth of the Delaware River year round with high concentrations of juveniles below Little Tinicum Island occurring year round. Adults may occur frequently at the Cherry Island Flats, and can occasionally be present within Delaware Bay. Thus, the operation of construction-related vessels at the Port will result in temporal and spatial overlap between vessels and juvenile and adult shortnose sturgeon.

8.5.2.4.2 Response

We currently do not know of any studies regarding how shortnose sturgeon respond to approaching vessels, but we assume that they do not actively avoid them as has been demonstrated for Atlantic sturgeon. We expect shortnose sturgeon to be located at or near the riverbed and, therefore, less likely to be exposed to entrainment in a tug's propeller. Further, a substantially lower number of shortsnose sturgeon carcasses have been reported from the Delaware River. Assuming that the low number of reported carcasses represents the true risk of a vessel interacting with a shortnose sturgeon, the risk of construction vessels interacting with shortsnose sturgeon during construction of the Edgemoor facility is low. However, as discussed in section 6.7.4, fewer shortnose sturgeon carcasses may be reported than Atlantic sturgeon carcasses (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 the risk of vessel strikes only within the lower Delaware River estuary only (i.e., not including the Delaware Bay and the Philadelphia to Trenton navigation channel where less traffic occurs). We also take into consideration the substantially increased risk of vessel strike within the Project Area and that large numbers of shortnose sturgeon are present in the lower Delaware River estuary during winter.

8.5.2.4.3 Risk

Given that it is likely that shortnose sturgeon are exposed to propellers and that a propeller striking a shortnose sturgeon will kill it, we conclude that the vessel traffic associated with the construction activities at the Port will kill shortnose sturgeon. These mortalities would not occur but for the proposed action.

8.5.2.4.4 Calculation of Take

Vessel strikes on shortnose sturgeon are not well documented. The DNREC data (2005 through 2019) identifies 13 shortnose sturgeon mortalities and the NJFW data (2013 to 2022) identifies four (4) shortnose sturgeon mortalities. Vessel strike was considered the cause of death for eight of the DNREC shortnose sturgeon and the cause of death is unknown for the remaining five. The four shortnose sturgeon in the NJFW spreadsheet were also unknown causes of death However, due to other identifiable sources of mortality such as predation, dredge interaction, bycatch, and entrainment in water intake systems, to be conservative, we consider all 17 as vessel strike mortalities. For the seven-year period from 2013 through 2019, 12 shortnose sturgeon carcasses were reported to DNREC and NJFW. Again, assuming that vessel strike caused all mortalities and that only 4.76 percent of all vessel mortalities are reported, we calculate that 252 vessel mortalities occurred during the eight years. Thus, one shortnose sturgeon is killed per 1,000 vessel trips or an adjusted mortality rate of 0.001[29]. Using the same calculation as above (adjusted mortality rate multiplied with number of vessel trips during construction at the Port), we expect that vessel activity related to the construction of the Port will kill 6 (5.4 rounded up) shortnose sturgeon over the 3 years of construction.

We do not have data to calculate the probability of the shortnose sturgeon being a juvenile or adult. Nor do we have enough data to predict the chance of a vessel strike being a female or male. Thus, the vessel strikes may be juvenile or adult shortnose sturgeon of either sex.

8.5.3 Consequences of Vessel Activity during Port Operation

As explained in the Project Description above, vessels will travel to the proposed Port using the Philadelphia to the Sea Navigation Channel during its operational lifetime. These vessels would not occur but for the proposed Port. 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. Therefore, project-related vessel traffic may increase the risk of lethal vessel strikes to Atlantic and shortnose sturgeon.

This section considers the effects to sturgeon from vessel traffic on the river and in the bay associated with the 50-year operation of the Edgemoor Port. First, we evaluated the factors determining the risk of vessel strikes. We then use the calculated number of sturgeon mortalities relative to vessel activity (vessel trips in the Navigation Channel) in the action area from section 6.3 to calculate an estimate of sturgeon killed per vessel trip. This is the calculated baseline mortality rate. We use this baseline mortality rate to calculate how many sturgeon will be killed by project related vessel activity (i.e., vessel trips calling at the Port during operation).

8.5.3.1 Vessel Activity

During operations, cargo vessels will make trips to and from the Port. Offshore cargo vessels will be approximately 180 m (590 ft) in length with a draft of approximately 9.1 m (30 ft). The USACE and Applicant expect up to 480 vessel calls annually. Of these, 362 vessel calls will be container vessels transferred from the Port of Wilmington and 118 calls will be new vessels resulting from the increased capacity at the Edgemoor Port relative to the current capacity at the

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[29] Mo = 6/282,891 = 0.0000476, Ma = 0.000048/0.0476 = 0.001. For description of calculations, see section 6.3.2.4.

Port of Wilmington. Cargo vessels will use the Philadelphia to the Sea Federal Navigation Channel to travel between the Port and the mouth of Delaware Bay.

The 118 additional container ships would result in an additional 236 large vessel trips per year in the river between the proposed port in Edgemoor and the sea. Although cargo vessels are capable of berthing themselves, these vessels will also likely be under tug control when berthing at the Port. Two to three tugs will be required to maneuver a cargo vessel. Tugs maneuvering cargo vessels will be up to approximately 32 m (105 ft) in length with a draft of approximately 4.6 m (15 ft). The above estimated number of vessel calls can be expanded to include the potential impact of support vessels (tugs) assisting in docking and undocking the container ships. If it is assumed that, on average, two tugs are required per container vessel trip, operation of the Edgemoor Port will result in an additional 472 additional tug trips per year (236 container ship trips x 2 tugs per ship = 472 tug trips) based on the conservative traffic estimate. Thus, the operation of the port will result in 708 (236 ship trips + 472 tug trips) new vessel trips annually.

The USACE has stated that the tugs' homeport is the Port of Wilmington and that they will travel to the Edgemoor Port from the existing Port of Wilmington Autoberth. The USACE has further stated that the Port of Wilmington is currently using tugs to turn container vessels as they approach the entrance to the Christina River to dock at terminals at the Port of Wilmington. They added that during the turning of vessels at the Port of Wilmington, the tugs do move within the 6.9 km (4.3 mi) stretch between the Christina River and the future site of the Edgemoor Port. They concluded that since a portion of the container vessels that will be calling at the Edgemoor Port consist of container business that will be transferred from the Port of Wilmington to the new Edgemoor facility, any tugs supporting turning of these vessels will not be new vessel traffic. Based on this, the USACE concluded that the tugs supporting the turning of 362 of the container vessels at Edgemoor will not be new vessel activity and will not increase vessel activity in the river over what is currently occurring. Therefore, we will not consider the consequences of these vessels here.

Vessels calling at the proposed Edgemoor port 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 6.2.2.2). 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 do 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. In addition to being an area of residency, the bay mouth is an area 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. While Atlantic sturgeon from non-natal DPSs may aggregate in the Bay, we expect that spawning New York Bight 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 the 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).

8.5.3.2 Risk Calculations

As discussed in section 8.5.2.2, we determined that the data from waterborne commerce vessels best represents what may expose sturgeon to vessel strike within the Delaware River and Bay. As we discussed in section 6.3, even though the data does not account for the recreational vessels and smaller fishing vessels that operate on the Delaware River and in the Bay, this data is a reasonable approximation of the vessel strike threat because the Waterborne Commerce dataset includes self-propelled vessels of all drafts. Thus, we believe that the commerce data provides a close approximation of the number of vessels that are a threat to sturgeon.

8.5.3.3 Atlantic Sturgeon

Juvenile and subadult Atlantic sturgeon may occur in the action area throughout the year, and adults are known to occur there seasonally. Therefore, the vessel traffic related to the proposed Port could interact with these life stages of Atlantic sturgeon and result in vessel strike mortalities.

8.5.3.3.1 Exposure

Vessel calls at the Edgemoor Marine Terminal during the 50 years of operation will occur at any time of the year from the Port to the pilot area at the mouth of the Delaware Bay. Transport of cargo will overlap with the presence of adult Atlantic sturgeon during spawning migrations from April into July. Vessels will also travel through the reach by Artificial Island where aggregations of subadult and adult sturgeon occur in late-summer and fall.

Cargo vessels will travel through the Delaware Bay mouth all year. During spring, summer and early fall months, subadult and adult Atlantic sturgeon aggregate and reside in areas at the mouth of the bay (section 6.2.2). These areas are relatively deep compared to the draft of incoming vessels, and Atlantic sturgeon at the seabed are unlikely to be exposed to the hydrology around the hull and propellers of the vessels. However, Atlantic sturgeon surfacing behavior will more readily expose individuals to vessels. Surfacing represents a small fraction of an individual's total behavior, but the chance that a vessel may interact with an individual increases when sturgeon aggregate. Because the Bay mouth is an area where higher densities and potentially larger aggregations of Atlantic sturgeon occur, the chance of a vessel interacting with a surfacing Atlantic sturgeon is relatively high (Breece *et al.* 2018). Thus, vessel traffic that would not occur but for the proposed action will overlap in space and time with potentially high concentrations of juvenile, subadult, and adult Atlantic sturgeon.

Similar to vessel exposure during construction, in early spring, mature adults migrate through the bay mouth during the spawning migration. Additionally, both subadults and adults move through the mouth during seasonal migrations to and from areas of residency within the Delaware Bay (Breece *et al.* 2018). We expect that spawning Atlantic sturgeon will move in a relatively straight line during migration through the Delaware Bay. This path largely corresponds 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 the 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 spawning Atlantic sturgeon enter the Delaware River during the spawning season, 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 during other directed movements (e.g., foraging or avoidance) (Balazik *et al.* 2012d, Fisher 2011, Reine *et al.* 2014). Consequently, Atlantic sturgeon are likely to occur at a depth that overlaps with the depth of the propeller of medium draft vessels (e.g., tugs) as well as deep draft vessels (e.g., cargo vessels) during periods when active movements occur such as spawning migration or seasonal movements between habitats.

Based on the above, there is a high likelihood that the operation of the Port will expose juvenile, subadult, and adult Atlantic sturgeon to moving vessels and their propellers. This exposure would not occur but for the proposed action.

8.5.3.3.2 Species' Response

Vessel traffic, consisting of commercial cargo ships, tankers, and tug boats have been identified as a significant source of Atlantic sturgeon mortality in the Delaware and James Rivers (Balazik *et al.* 2012c, 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, which entrain sturgeon.

Sturgeon entrained in the propeller of vessels could also be injured but survive. This would be most likely to occur for younger and smaller juveniles or if interacting with a smaller propeller than those expected on the cargo vessels. The vessels calling at the proposed Port 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 Opinion to be fatal.

8.5.3.3.3 Risk

Given that it is highly likely that Atlantic sturgeon are exposed to the propellers of vessels moving to and from the mouth of the Delaware Bay and the Port, and that a propeller striking an

Atlantic sturgeon will kill it, we conclude that there is a high risk of the vessel traffic associated with the proposed action killing Atlantic sturgeon. This mortality would not occur but for the proposed action.

8.5.3.3.4 Calculation of Take

Based on the above, we calculated that the adjusted baseline mortality rate (or Atlantic sturgeon killed per vessel trip on average) as 0.0091[30]. This equates to one vessel strike per approximately 110 vessel trips.

The USACE estimates that the operation of the proposed Port will add 35,400 new vessel trips (708 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 50-year life span of the project. Thus, approximately 323 sturgeon will be killed by the additional vessel trips) over the 50-years of Port operations (7 per year (rounded up from 6.46)).

As discussed in section 6.2.2.3, the vessel strike databases from DNREC and NJFW are considered the best available source of information from which we can estimate the life stages of Atlantic sturgeon vessel strike mortalities. However, the vessel strike databases are limited in their applicability due to limitations in identifying sturgeon lengths from damaged, often decayed remains. Therefore, it is not always possible to distinguish life stages, so we identify subsets of data from the available information. For example, the lists of sturgeon was limited to those whose cause of death was identified as “vessel strike” or “unknown”, the list was further limited to those with enough of a body to identify approximate length (or enough of a body to identify maturity stage where possible).

In addition, the databases cover different time intervals. The DNREC data spans the years 2005 to 2019. There are 180 records for Atlantic sturgeon from the Delaware River and Bay that include cause of death as either vessel or unknown for that whole period. However, of those 180, we were able to assign life stage information for only 153. The NJFW database includes reports from the years January 2013 to May 2022. Over that period, the database has 23 Atlantic sturgeon that were either considered vessel strike mortalities or unknown. Of these 23, 12 could be assigned a life stage. The DNREC and NJFW data overlap between 2013 and 2019, which NEFSC used for their analysis. Between 2013 and 2019, life stages could be assigned to 78 Atlantic sturgeon in the DNREC data, and 11 from the NJFW database.

NEFSC’s analysis of the Atlantic sturgeon vessel strike data from DNREC and NJFW determined that 44 were adults, 15 subadults, and 19 juveniles. Of the 11 Atlantic sturgeon in the NJFW data that we consider as struck by vessels, six were determined to be adults and five as subadults based on their length. None of the carcasses were determined to be a juvenile. Therefore, of the 89 Atlantic sturgeon killed by vessel strike in the DNREC and NJFW data that NEFSC reviewed, 19 were assigned as juveniles, 50 as adults, and 20 as subadults. Thus, of the

[30] Mo = 109/252,091 = 0.000432, Ma = 0.000432/0.0476 = 0.0091. For description of calculations, see section 6.3.2.3

89 carcasses with an assigned life stage, 56.18 percent were adults, 22.47 percent were subadults, and 21.35 percent were juveniles (Table 17).

Table 17. Sturgeon vessel strike mortality by life stage in the Delaware River.

Stage	All Sturgeon (n)	All Sturgeon (%)	DNREC Sturgeon (n)	DNREC Sturgeon (%)
Adult	50	56.18	44	56.41
Subadult	20	22.47	15	19.23
Juvenile	19	21.35	19	24.36

Although studies by Murphy and Brown (2010) determined that 61 percent of Atlantic sturgeon vessel strike mortalities in the Delaware River were of adult size (150 cm TL), because they did not differentiate between subadult and non-migrant juveniles for the remaining non-adults, we must use the information from the vessel strike databases. 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 life stage mortality rates based on reporting bias or carcass persistence time. Only considering carcasses with enough information to determine life stage, adults and subadults made up 78.65 percent of the vessel strikes reported to DNREC and NJFW. Using this percentage, we anticipate that 69 juveniles will be killed over the life of the project. The 69 juvenile Atlantic sturgeon will be from the New York Bight DPS.

Consequences of Vessel Activity on Atlantic Sturgeon by DPS

Above, we concluded that the operation of the Port is likely to result in 323 vessel strike mortalities that would not occur but for the proposed project. We have considered the best available information to determine the likely DPS origin of subadult and adult individuals. We previously used the Damon-Randall *et al.* (2013) mixed stock analysis of Atlantic sturgeon in the Delaware River to determine the percentage of takes from each DPS. Busch (2022) recently completed a Master's of Science thesis on a mixed stock analysis of Atlantic sturgeon based on tissue samples collected from fish from coastal areas of Delaware, the Delaware Bay, and the Delaware River. This is the most recent mixed stock analysis of Atlantic sturgeon that includes the action area. However, the results of that study did not differ significantly from what has been reported in previous mixed stock analyses of Atlantic sturgeon from coastal Delaware and New Jersey, especially the results in (Damon-Randall *et al.* 2013). Therefore, we will continue to use Damon-Randall *et al.* (2013) to determine take by DPS. However, the NEFSC recently reviewed the data used by Damon-Randall *et al.* (2013) and recommended that we use the rates for the Estuarine/Riverine Zone #3 rather than the Marine Mixing Zone #2 rates presented in Damon-Randall *et al.* (2013) report. The NEFSC also recommended that if analyses can split trips between the Estuary and River portions, we should apply the Hudson River rates to the "the upper and middle portions of each river" and the Estuary/Coastal rates to the "lower river and coastal" portions. Approximately 55 percent of the carcasses reported to DNREC were found in the Delaware River and the remaining were found in the Bay. However, we cannot relate the number of vessel strike mortalities in the river to the number of vessel trips in the river because the Waterborne Commerce Data does not allow for partitioning trips between the river and bay. Thus, we will apply the Estuarine/Riverine Zone #3 rates to all of the vessel strikes to estimate how many are expected to belong to each DPS.

Using the Estuarine/Riverine mixed stock analysis, Atlantic sturgeon exposed to commercial vessel traffic of the proposed action originate from the five DPSs at the following frequencies: NYB 42 percent; Chesapeake Bay 24 percent; South Atlantic 20 percent; Gulf of Maine 13 percent, and Carolina 1 percent (Damon-Randall *et al.* 2013). Based on these percentages, we have estimated that 33 adult/subadult vessel mortality will belong to the Gulf of Maine DPS, 176 (107 adult/subadult and 69 juvenile) to the New York Bight DPS, 61 adult/subadult will belong to Chesapeake Bay DPS, 51 adult/subadult to South Atlantic DPS, and 2 adult/subadult to the Carolina DPS.

Using additional mixed stock analyses available to us that included river distribution information in their DPS determinations, we were able to estimate the percentage of New York Bight DPS Atlantic sturgeon originating from the Hudson and Delaware Rivers. These studies 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 (Busch 2022, Kazyak *et al.* 2021, Wirgin *et al.* 2015a, Wirgin and King 2011). Wirgin *et al.* (2015b), which sampled migrating Atlantic sturgeon from an area 3 to 12 km (1.9 to 7.5 mi) from the Delaware coast, found that 10.6 percent of all the fish sampled were from the Delaware River and 44 percent were from the Hudson River. Kazyak *et al.* (2021) found that 37.5 percent of individuals sampled from the mid-Atlantic region (Cape Hatteras to Cape Cod) were assigned to populations in the New York Bight DPS. For the total sample, 11.4 percent were Delaware River fish and the remaining 26.2 percent were Hudson River fish. We note that the sample seems to include juveniles (defined as <500mm TL) from the Delaware River which suggests some in-river sampling. A recent (2022) master's thesis conducted a mixed stock analysis of tissue samples collected from adult and subadult Atlantic sturgeon caught in the Delaware River estuary, Delaware Bay, and in coastal waters off Delaware (Busch 2022). The study found that 8.3 percent of all fish samples were Delaware River fish and 41.8 percent were Hudson River fish. Given these results, the proportion of Delaware and Hudson River Atlantic sturgeon are shown in Table 43.

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) while only one of the carcasses reported to the NJFW had a sex determination. Of these, two were determined to be female and four 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, the adult/subadult vessel strike mortalities estimated over 50 years of Port operation could be either male or female.

8.5.3.4 Shortnose sturgeon

Juvenile and adult shortnose sturgeon may occur in the action area throughout the year. Therefore, the vessel traffic associated with the proposed Port could interact with these life stages of shortnose sturgeon and result in vessel strike mortalities.

8.5.3.4.1 Exposure

Vessel activity will occur from the Port to the pilot area at the mouth of Delaware Bay during the 50 years of operation of the Port. Vessel activity will occur year round. Both juvenile and adult shortnose sturgeon occur from Trenton, New Jersey, downstream to the mouth of the Delaware River year round with high concentrations of juveniles below Little Tinicum Island occurring year round. Adults may occur frequently at the Cherry Island Flats, and can occasionally be present within Delaware Bay. Thus, inbound and outbound transport of cargo will result in temporal and spatial overlap between these vessels and juvenile and adult shortnose sturgeon from the mouth of the Delaware River to the Port, with additional potential exposure between the vessels and adult shortnose sturgeon within the Delaware Bay.

Since all vessels will mostly travel within the 14-meter deep navigation channel, and foraging sturgeon are likely to remain close to the bottom, direct exposure to the propellers of the 7.3-meter-draft cargo vessels, while actively foraging, may occur infrequently. However, we expect shortnose sturgeon to move higher in the water column during other behaviors (i.e., moving to and from foraging and spawning areas, migrations) and this will likely place the fish in the water column at the same depth as the propellers of cargo vessels associated with the operation of the Port. Based on the above information, there is a high likelihood that the operation of the Port will expose juvenile and adult shortnose sturgeon to vessels and their propellers in a manner that would not occur but for the proposed action.

8.5.3.4.2 Response

We currently do not know of any studies regarding how shortnose sturgeon respond to approaching vessels, but we assume that they do not actively avoid them as has been demonstrated for Atlantic sturgeon. We also expect that the water current moving through the propellers of tugs and larger vessels can entrain shortnose sturgeon, similarly to Atlantic sturgeon, exposing them to the rotating propellers. Smaller shortnose sturgeon may go through a propeller without interacting with the blades, whereas propeller blades are likely to strike entrained older, larger adult sturgeon (section 8.5.1). As with Atlantic sturgeon, we anticipate that any interaction with propeller blades of large vessels will be lethal.

8.5.3.4.3 Risk

Given that it is likely that shortnose sturgeon are exposed to propellers and that a propeller striking a shortnose sturgeon will kill it, we conclude that the vessel traffic associated with the proposed action will kill shortnose sturgeon. These mortalities would not occur but for the proposed action.

8.5.3.4.4 Calculation of Take

Vessel strikes on shortnose sturgeon are not well documented. The DNREC data (2005 through 2019) identifies 13 shortnose sturgeon mortalities and the NJFW data (2013 to 2022) identifies four (4) shortnose sturgeon mortalities. Vessel strike was considered the cause of death of eight of the DNREC shortnose sturgeon and the cause of death is unknown for the remaining five. The causes of death for the four shortnose sturgeon in the NJFW spreadsheet were recorded as unknown. However, because other sources of mortality are often identifiable, such as predation, dredge interaction, bycatch, and entrainment in water intake systems, to be conservative, we consider all 17 as vessel strike mortalities. For the seven year period from 2013 through 2019, 12 shortnose sturgeon carcasses were reported to DNREC and NJFW. Again, assuming that vessel strike caused all mortalities and that only 4.76 percent of all vessel mortalities are reported, we calculate that 252 vessel mortalities occurred during this period. Thus, one shortnose sturgeon is killed per 1,000 vessel trips or an adjusted mortality rate of 0.001. Using the same calculation as above (adjusted mortality rate multiplied with number of vessel trips during operation of the Port), we expect the operation of the Port to cause one (rounded up from 0.7) vessel strike per year. Therefore, over the life of the project, 50 shortnose sturgeon will be killed by vessel activity related to the operation of the Port. We do not have data to calculate the probability of the shortnose sturgeon being a juvenile or adult. Nor do we have enough data to predict the chance of a vessel strike being a female or male. Thus, the vessel strike may be a juvenile or an adult shortnose sturgeon of either sex.

8.5.4 Summary of Consequences of Vessel Traffic

Based on information in the biological assessment, the construction of the Port will add 5,442 vessel trips over a three year period and the operation of the Port will add 708 vessel trips per year during the 50 years of operations to the number of baseline vessel trips. We expect the additional vessel traffic in the action area due to the construction and the operation of the Port will increase the risk of vessel strike in the action area. We assume that vessels calling at the Port will stay constant and that the risk will not increase during the years of operation. Based on this, we have estimated the number of shortnose sturgeon and Atlantic sturgeon that will be killed as a consequence of the proposed action. We used the Estuarine/Riverine Zone 3 breakdown of DPS from Damon-Randall *et al.* (2013) to estimate how many Atlantic sturgeon of each DPS we expect will be killed by vessel strike. Table 41 summarizes the number of sturgeon vessel strike mortalities by species, life stage, and DPS.

Table 41. Number of shortnose sturgeon and Atlantic sturgeon of each DPS expected to be killed by vessel traffic during operation of the proposed Port.

Species	DPS	Juvenile	Subadult	Adult	Either Subadult/ Adult	Either juvenile or adult/subadult
Atlantic sturgeon	GOM	0			33	0
	NYB	69	31	76		0
	CB	0			61	0
	SA	0			51	0
	CA	0			2	
Shortnose sturgeon	N/A	-			-	50

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 number of vessel strike mortalities by recreational vessels is very small and thus, 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.
- That all vessels are equally likely to strike a sturgeon and that the effects of that strike would be the same, which could result in an underestimate or overestimate if not true.
- That the sturgeon recorded in the DNREC and NJFW databases without any identified cause of death were considered vessel strike mortalities, which would overestimate the risk of vessel strike if many of these were actually not killed by interaction with vessels.
- That the DNREC and NJFW databases include only 4.76 percent of actual sturgeon mortalities in the Delaware River and Bay, which would result in overestimate of vessel strikes if a higher proportion is reported and an underestimate if even fewer are reported.
- The use of annual vessel activity and sturgeon mortalities to calculate vessel strike risk 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 Port are likely to exchange ballast during on- and offloading of cargo. However, it is unclear where exactly the exchange of ballast will occur. Thus, we assume that exchange of ballast could occur within the Federal Navigation Channel as well as at the Port. 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. Juveniles and older sturgeon life stages in the action area are too large to potentially be entrained and have sufficient swimming capabilities to avoid impingement during ballast water withdrawal (NMFS 2017a). Fish eggs and larvae have the potential to be entrained during the intake of ballast water. Sturgeon eggs, yolk-sac larvae, and post yolk-sac larvae are not expected to occur within the Port and its access channel.

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 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.

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 118 (RM 73.3) 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; however, the action area within critical habitat is limited to the Project Area and the Federal Navigation Channel (see section 4).

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, extremely unlikely 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, low salinity waters consistent with PBF 1 could occur within the action area from RKM 107.8 to 118 (RM 67 to 73.3) depending on where the salt front is in a particular year; however, the nearest hard bottom substrate that may be used by Atlantic sturgeon for spawning is located 7 km (4.3 mi) upriver of the Port site. Bottom substrate within the Port area consists of fine-grained sediments (silt/clay/sand) (Figure 17). Thus, PBF 1 is not present within the action area and there are no project-related effects to PBF 1.

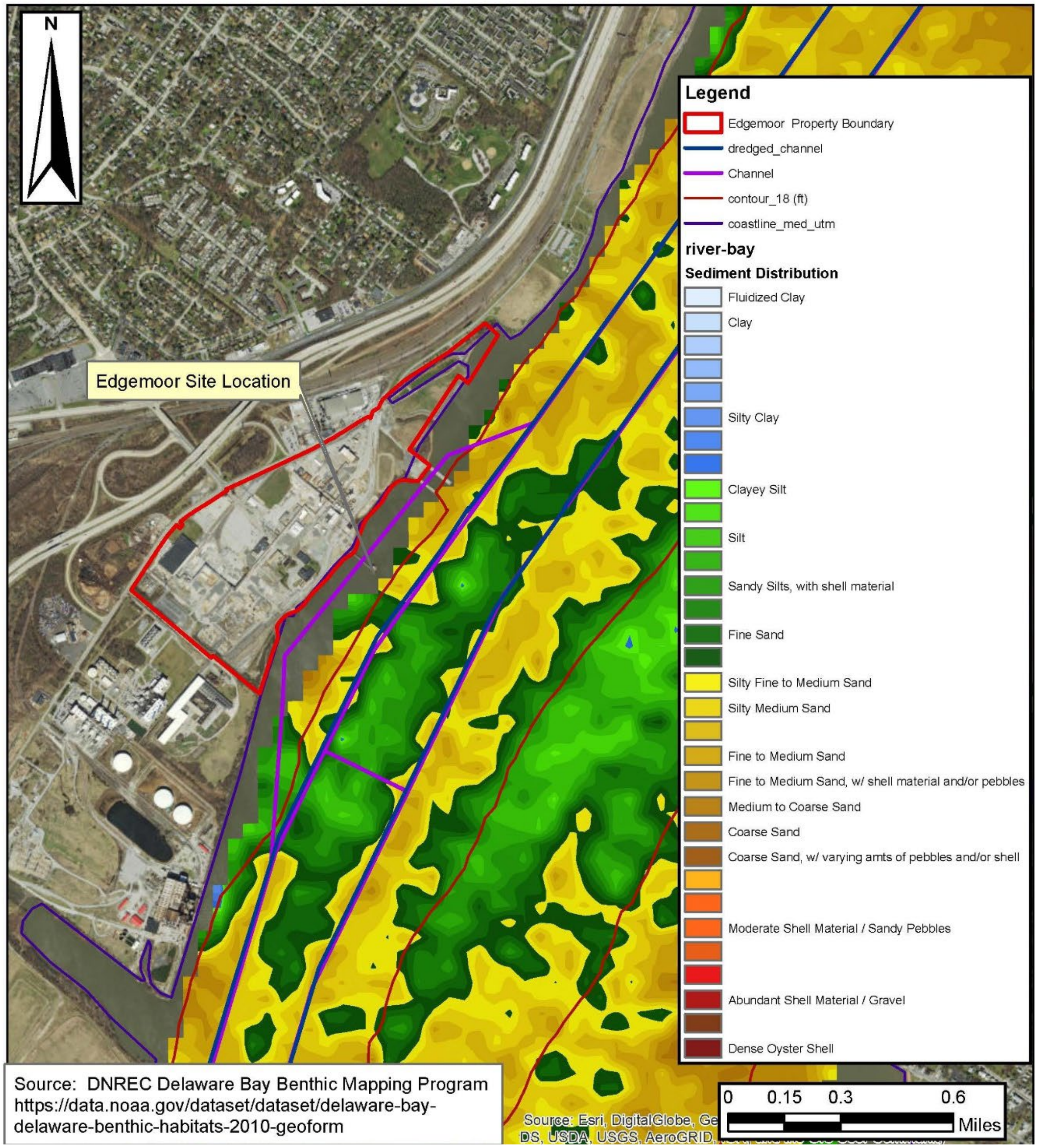

Figure 17. Benthic mapping of Delaware River substrate at Edgemoor site location

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 (RM 48.5) (where the final rule describes the mouth of the river entering Delaware Bay) to approximately RKM 107.8-122.3 (RM 67-76) or the current median salt front location range. The location of the Port at RKM 118 (RM 73.3) is within the median range of the salt front. As explained in section 6.2.3, we estimate the area of bank-to-bank critical habitat from RKM 78-118 (RM 48.5-73.3) is 34,240 acres, of which 3,165.5 acres are the action area for the proposed Port (2,230 acres of Federal Navigation Channel and 935.5 acres at the project site). If we assume that benthic communities in the action area will be degraded to some degree by propeller wash and dredging and subtract that area from the available PBF 2 in the river, the area of potential higher quality PBF 2 habitat amounts to 31,923 acres.

As described above, initial dredging will result in the removal of up to 3,300,000 cy of material to a depth of -13.7 m (-45 ft) within approximately 87 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 87 acres, as areas outside of the dredge footprint impacted by sedimentation from the nearfield turbidity plume of the cutterhead dredge 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 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.

Following dredging, the ability of the 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.

As discussed in section 3.5, scour from propeller jets can scour several centimeters deep into the substrate. However, we expect any consequences from a vessel propeller outside of the Federal Navigation Channel will be of short duration and 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 (6 to 12.6 inches) 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). Vessel traffic during operation of the Port will be concentrated in the access channel and turning basin, and 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 Port may permanently disturb the soft substrate and benthic community, reducing the quality of PBF 2 within the approximately 87 acres of the access channel, turning basin, and berths.

The Philadelphia to the Sea Navigation Channel and Port action area constitutes approximately 3,165.5 acres of the 34,240-acre shore-to-shore area (~9.2 percent) between RKM 78 and 118 (RM 48.5-73.3). All of this area consists of soft substrate; however, with thousands of deep draft vessels traveling up and down the navigation channel, the channel bottom is also regularly impacted from prop wash. 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 3,165.5 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 3,165.5 acres (the action area) to provide PBF 2 that is suitable and valuable for conservation of the species.

The area dredged to create the access channel, turning basin, and berthing will permanently degrade or remove approximately 87 acres or 2.7 percent of PBF 2 within the 3,165.5-acre action area over the next 53 years (up to 3 years of construction and 50 years of operation). In addition, vessels that will travel to and from the Port using the Federal Navigation Channel may scour the soft bottom substrate within the channel. Combined, the dredge footprint and Federal Navigation Channel comprise 2,317 acres (73 percent) of PBF2 in the action area. 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, particularly given that, as we note above, with thousands of deep draft vessels traveling up and down the Navigation Channel, the channel bottom is also regularly impacted from prop wash and accordingly, PBF2 within the channel is likely degraded. 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 is located within the oligohaline zone of the river. The mesohaline zone represents a gradual shift in salinity from the upstream oligohaline zone into the downstream polyhaline waters of the Delaware Bay. Therefore, the action area provides an area where Atlantic sturgeon juveniles acclimate to increasing salinity before moving into the mesohaline zone, the polyhaline Delaware Bay, and eventually marine waters. This reduction in the amount and quality of soft bottom substrate means that, within the action area, there will be significantly less aquatic habitat available for juvenile foraging and physiological development as juveniles transition to migrant subadults. We expect this to result in an adverse 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 New York Bight 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 because shallow water can be a barrier to sturgeon movements, and an alteration in water flow could similarly affect 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 that is within critical habitat 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. At this time, we are not aware of any anthropogenic impacts 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 Port and vessel transit routes. Here, we consider whether those activities may affect PBF 3 and, if so, whether those consequences are adverse, insignificant, extremely unlikely, or entirely beneficial.

The proposed Port involves construction of a pile-supported wharf and dredging to create an access channel, turning basin, and berthing. The wharf will be constructed parallel to the shoreline and extend 34.1 m (112 ft) into the river. The width of the River at the Port is approximately 2.4 km (1.5 mi), and the proposed wharf 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. The width of the navigation channel, turning basin, and access channel for the Edgemoor project will be at most 503 m (1,650 ft), whereas the total river width at the project site is approximately 2.4 km (1.5 mi). Even if a sturgeon was to completely avoid the navigation channel-turning basin-access channel when a vessel was maneuvering, over 75 percent of the river width would remain unaffected by such maneuvering. It should also be considered that vessel maneuvering to or from the berth is a temporally very limited (taking approximately 10 to 15 minutes per docking/undocking event) (MITAGS, 2018) and infrequent (2 to 3 times per day) event. Anchoring of container ships calling on the Edgemoor port is not anticipated to occur. 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 section 6.1.2. Based on this information, PBF 4 exists in the action area from RKM 118 (RM 73.3) downstream to RKM 78 (RM 48.5) where the Delaware River empties into the Delaware Bay. 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 (299 ft) 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 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 State DEPs. 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 Port will have adverse effects to PBF 2. In the *Integration and Synthesis* (section 11), 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. PBFs 1 is not present in the action area and therefore there are no consequences to PBF 1 and consequences to PBFs 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."

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. 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[31]. The activities discussed in the Cumulative Effects section of the 2011 EA developed for the deepening project – the Paulsboro Marine Terminal and the Southport Marine Terminal require authorization by the US Army Corps of Engineers, therefore they are considered Federal actions and do not meet the definition of "cumulative effects" under the ESA. USACE have stated that both of these actions involve dredging up to 12 m (40 ft) and are not dependent on this project; thus, they cannot be considered consequences of the action.

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. Permit holders 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.

[31] 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 of the Action* section, we considered potential consequences from the construction (including dredging and pile driving) and operation of the Port as well as the activities at the mitigation sites. These consequences include interactions with 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 Port 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), and no take is anticipated or exempted for these species.

We have estimated that the proposed project will result in dredging entrapment of up to three sturgeon (no more than one per dredge cycle). The killed fish will be either shortnose sturgeon or juvenile New York Bight DPS Atlantic sturgeon. We also concluded that vessel traffic during construction will result in the mortality of six shortnose sturgeon and 14 New York Bight DPS Atlantic sturgeon (11 adult and 3 juvenile) while interactions with vessels during operation of the Port will result in the mortality of 50 shortnose sturgeon and 323 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 extremely unlikely.

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, "[i]mprovement 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.

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 (248.5 mi). 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 DNREC (2005-2019) and NJFW (2013-2022), indicate that 8 sturgeon mortalities were attributable to vessel strikes (and an additional 9 had an unknown, but likely vessel strike 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, we obtain some information on the number of incidental and directed takes of shortnose sturgeon each year from specific actions. 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 dredging will kill up to three (3) shortnose sturgeon during 3 years of construction. Each may be either juveniles or adults.
- We anticipate that vessel traffic during 3 years of construction will kill six (6) shortnose sturgeon and that vessel traffic to and from the Port during 50 years of port operations will result in 50 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 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.

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 59 juvenile or adult shortnose sturgeon during the completed activities over a 53-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 m (1,640 ft) 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 may diminish the availability of prey in the access channel and turning basin of the proposed Port; 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 less than 0.5 percent 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.

In general, 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* sections above), and there are thousands of shortnose sturgeon spawning each year.

Based on the information provided above, the death of up to 59 shortnose sturgeon juveniles or adults as a result of the proposed action 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 59 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, which together constitutes approximately only 6.7 percent of soft bottom substrate within the saline portion of the tidal Delaware River. Impacts to habitat will be limited to the temporary loss of forage within the dredge footprint, continued degradation of forage within the dredge footprint by propeller jet scour, 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 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. We have also 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 is not likely to appreciably reduce the survival and recovery of this species.

Atlantic Sturgeon

As explained above, the proposed action is likely to result in the incidental take of up to 340 Atlantic sturgeon from the Gulf of Maine, New York Bight, Chesapeake Bay, South Atlantic, and/or Carolina DPSs during cutterhed dredging (3) in the Delaware River and as a result of vessel interactions during construction (14) and in the 50 years of operation (323). 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) 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 extremely unlikely.

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.

We expect the proposed cutterhead dredging to kill up to three sturgeon (no more than one per dredge cycle). The fish killed could be either shortnose sturgeon or Atlantic sturgeon. All Atlantic sturgeon would be juveniles. Thus, any Atlantic sturgeon killed as a consequence of dredging will be of New York Bight DPS origin.

We expect that up to 14 Atlantic sturgeon will be killed by vessel strike during construction of the proposed Port. We expect that all Atlantic sturgeon killed will be of the New York Bight DPS because vessels are most likely to interact with juveniles rearing in the reach and pre and post migration adults. Of these, 11 will be adult and 3 will be juvenile.

We expect that up to 323 Atlantic sturgeon will be killed by vessel strike during operation of the proposed Port. Of these, we estimate that up to 254 will be adults or sub-adult and up to 69 to be juveniles. The juveniles will be of New York Bight DPS origin.

Using mixed stock analysis explained in section 5.2.2.2, 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: 107 will originate from the New York Bight DPS, 61 from the Chesapeake Bay DPS, 51 from the South Atlantic DPS, 33 from the Gulf of Maine DPS, and 2 from the Carolina DPS.

- Up to 76 adult Atlantic sturgeon from New York Bight DPS
- Up to 31 sub-adult Atlantic sturgeon from the New York Bight DPS
- Up to 61 adult or sub-adult Atlantic sturgeon from Chesapeake Bay DPS
- Up to 51 adult or sub-adult Atlantic sturgeon from South Atlantic DPS
- Up to 33 adult or sub-adult Atlantic sturgeon from Gulf of Maine DPS
- Up to 2 from the Carolina DPS

In addition, we expect that 14 Atlantic sturgeon will be killed by vessel strike during construction of the Port. We expect three sturgeon to be juvenile and11 adult Atlantic sturgeon of New York Bight DPS origin.

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

Table 42. Estimated total lethal take for Atlantic sturgeon from the proposed Port.

DPS	Take
New York Bight	Up to 193
Chesapeake	Up to 61

South Atlantic	Up to 51
Gulf of Maine	Up to 33
Carolina	Up to 2

Gulf of Maine DPS

The Gulf of Maine 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, although not confirmed. 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 Gulf of Maine 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 (2017b). 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 33 Atlantic sturgeon over a 50-year period from the Gulf of Maine DPS. The reproductive potential of the Gulf of Maine DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of up to 33 individuals over a 50-year period will have the consequence of reducing reproduction potential within the DPS because any dead Gulf of Maine 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 individuals that will 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 Gulf of Maine 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 Gulf of Maine DPS fish for the same reasons.

Because we do not have a population estimate for the Gulf of Maine 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 33 individuals over a 50-year period, or an average of 0.66 mortalities each year, it is unlikely that this death will have detectable consequences on the numbers and population trend of the Gulf of Maine 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 Gulf of Maine 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 33 Gulf of Maine DPS Atlantic sturgeon over a 50-year period will not appreciably reduce the likelihood of survival of the Gulf of Maine 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 Gulf of Maine 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 33 Gulf of Maine DPS Atlantic sturgeon as a result of this action in any year will not change the status or trends of the species as a whole; (2) the loss of these 33 Gulf of Maine DPS Atlantic sturgeon as a result of this action 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 Gulf of Maine 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 Gulf of Maine DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging Gulf of Maine 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 Gulf of Maine 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 Gulf of Maine DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the Gulf of Maine 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 Gulf of Maine 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 50 years (33 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 Gulf of Maine DPS of Atlantic sturgeon. The action will not change the status or trend of the Gulf of Maine 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 Gulf of Maine 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 Gulf of Maine 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 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 33 Gulf of Maine DPS Atlantic sturgeon over a 50-year period, is not likely to appreciably reduce the survival and recovery of the species.

New York Bight DPS

The New York Bight DPS is listed as endangered and 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. Our recent status review concluded that the status of the DPS has likely neither improved nor declined from what it was when we listed the DPS in 2012, that the DPS's demographic risk is "High," and that no changes to the listing status and listing recovery priority number are needed (NMFS 2022). As noted in the 5-year review and discussed in section 5.2.2.3, low productivity (e.g., relatively few adults compared to historical levels and irregular spawning success), low abundance (e.g., only a few known spawning populations and low DPS abundance, overall), and limited spatial distribution (e.g., limited spawning habitat within each of the few known rivers that support spawning) puts the New York Bight DPS at risk of extinction. There is also new information indicating genetic bottlenecks as well as low levels of inbreeding in the Hudson and Delaware spawning populations.

Within the New York Bight DPS range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Housatonic Rivers (ASSRT 2007, Murawski and Pacheco 1977, Secor *et al.* 2002). 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 present in all the New York Bight DPS rivers (82 FR 39160; August 17, 2017). However, currently, there is no evidence that spawning is occurring nor are there studies underway to investigate spawning occurrence in the Connecticut and Housatonic Rivers; except one recent study where young-of-the-year fish were captured in the Connecticut River (Savoy *et al*. 2017). Genetic analysis suggests that the young-of-the-year fish belonged to the South Atlantic 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.

Here we evaluate the consequences to the New York Bight DPS of Atlantic sturgeon as a result of the lethal take of 193 Atlantic sturgeon over a 53-year period (construction and operation of the Port). In sections 6.2.2.3 and 6.2.2.4, we provided information that we relied on to determine the percentage of New York Bight DPS adult and subadult fish within the action area as well as the percentages that are likely to originate from the Delaware River versus the Hudson River. Although we have information regarding life stages and rivers of origin for Atlantic sturgeon from the New York Bight DPS to evaluate the impacts of vessel strikes, at this time, we cannot reasonably predict where vessel strikes will occur.

Given the sizes of the two New York Bight DPS populations and the fact that the Delaware River population is thought to be considerably smaller than the Hudson River population see discussion below, the worst case scenario is that all New York Bight fish that will be killed will be Delaware River fish; however, that appears to be unlikely. A genetic analysis of 150 Atlantic sturgeon incidentally captured at the Salem Nuclear Generating Station located at Artificial Island approximately 34 km (21 mi) downstream of the Port, but within the action area, found that 106 were from the New York Bight DPS, with 57 originating from the Delaware River and 49 from the Hudson River (NMFS 2023). This suggests that within the action area, which includes the Federal Navigation Channel that is west of Artificial Island, the composition of New York Bight DPS fish is approximately 54 percent Delaware and 46 percent Hudson. However, the analysis at Salem included Atlantic sturgeon with a total length of 760 mm or shorter, which are likely to be juveniles. Thus, because other studies are available that include samples from other parts of the Delaware River, Estuary, and Bay and more accurately represent the composition of Atlantic sturgeon potentially impacted by the proposed action, we cannot use this information alone to determine the percentages of Delaware River and Hudson River origin subadult and adult Atlantic sturgeon.

We have reviewed additional mixed stock analyses available to us that included river distribution information within the DPS determinations. These studies 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

(Busch 2022, Kazyak *et al.* 2021, Wirgin *et al.* 2015a, Wirgin and King 2011). Wirgin *et al.* (2015a), which sampled migrating Atlantic sturgeon from an area 3 to 12 km from the Delaware coast, found that 10.6 percent of all the fish sampled were from the Delaware River and 44 percent were from the Hudson River. Kazyak *et al.* (2021) found that 37.5 percent of individuals sampled from the mid-Atlantic region (Cape Hatteras to Cape Cod) were assigned to populations in the New York Bight DPS. For the total sample, 11.4 percent were Delaware River fish and the remaining 26.2 percent were Hudson River fish. We note that the percentage of Delaware River fish may be high because it includes juveniles (defined as <500mm TL) from the Delaware River. A recent (2022) master's thesis conducted a mixed stock analysis of tissue samples collected from adult and subadult Atlantic sturgeon caught in the Delaware River estuary, Delaware Bay, and in coastal waters off Delaware (Busch 2022). The study found that 8.3 percent of all fish samples were Delaware River fish and 41.8 percent were Hudson River fish. Given these results, the proportion of Delaware and Hudson River Atlantic sturgeon as shown in Table 43 support the conclusion that the Hudson River population is more robust than the Delaware River population.

Table 43. Proportion of Delaware and Hudson River Atlantic sturgeon.

Study	Sample Source	Sample Area	DER	HUR	TOTAL	DER%	HUR%
Wirgin *et al.* (2015b)	Fishery-independent sampling targeted for migratory Atlantic Sturgeon	3 to 12 km from the coast in the vicinity of Bethany Beach, Delaware	13.8	38.3	52.1	26.5	73.5
Kazyak *et al.* (2021)	Selection by the NMFS	**Mid Region:** Cape Hatteras to Cape Cod including catches from river and estuaries	11.4	26.2	37.6	30.3	69.7
Busch (2022)	Samples provided by Dr. Dewayne Fox through Delaware State University	Delaware River and Bay (2005-2009), marine waters of coastal Delaware (2009-2017),	8.3	41.8	50.1	16.6	83.4

		entrance to the Delaware Bay (2019-2020)					
Wirgin *et al.* (2015a)	NOAA's Northeast Fisheries Observer Program	GOM to Cape Hatteras	8.7	42.2	50.9	17.1	83

For this Opinion, we have calculated the average river distribution result from the studies described above and applied it to the estimated take of New York Bight Atlantic sturgeon at the river origin level. We calculated that of the total New York Bight DPS mixed stock percentage in the action area 23 percent is the average percentage of Delaware River fish and 77 percent is the average percentage of Hudson River fish occurring throughout the action area. When applied to the 87 adult New York Bight Atlantic sturgeon takes, we estimate that 20 would be Delaware River fish and 67 would be Hudson River fish. When applied to the 31 subadult New York Bight Atlantic sturgeon takes, we estimate that 7 would be Delaware River fish and 24 would be Hudson River fish. Finally, when applied to the New York Bight DPS Atlantic sturgeon takes, we estimate that all 75 juveniles will be Delaware River fish.

As discussed in section 6.2.2.4, we reviewed sturgeon carcasses reports available to us from the Delaware River and Bay to calculate the number of adult and subadult New York Bight Atlantic sturgeon. To separate the number of adult and subadult takes, we need an estimate of vessel strike mortality by life stage, but separate subadult and adult reporting rates are currently unknown. The best available information to calculate this rate are the Atlantic Sturgeon Carcass Databases provided by DNREC and NJFW (see Table 17). The list of sturgeon was reduced to those whose cause of death was identified as "vessel strike" or "unknown," the list was further reduced to those with enough of a body to identify approximate length (or enough of a body to identify maturity stage where possible). For this qualitative analysis, subadults ranged from 76-150 cm (29.9-59 in) and juveniles are less than 76 cm (29.9 in), unless identified as a different stage by the sturgeon biologist in the database.

With the life stage rates derived from the Vessel Strike Database, we simply apply stage-specific rates to the estimates of takes as follows:

$$N_{stage} = N * S_{stage}$$

where N_{stage} is the number of sturgeon of a particular life stage killed over the operational period of a project from vessel strikes, N is the total number of sturgeon killed over the operational period of a project from vessel strikes, and S_{stage} is the percentage of vessel strike mortalities by life stage of New York Bight sturgeon. Number per year is calculated as performed before, by dividing N_{stage} by the operational life of the project (L).

Table 44. New York Bight DPS Atlantic sturgeon takes incidental to vessel operations during construction and operation.

Project Stage	Project Total	Project NYB	Project NYB Adults	Project NYB Subadults	Project NYB Juveniles	Annual NYB Adults	Annual NYB Subadults	Annual NYB Juveniles
Operation	323	176	76	31	69	1.52	0.62	1.38
Construction	14	14	11	0	3	3.6	1	1

Males may be more likely to interact with vessels than females based on behavioral differences between males and females during spawning. The DNREC data report the sex for only five adult mortalities (all mortality causes) in the Delaware River (all years) while only one of the carcasses reported to the NJFW had a sex determination. 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 likely to be struck and killed by a vessel as female sturgeon. Therefore, out of the 87 adult and 31 subadult vessel strike mortalities estimated for the New York Bight DPS over 53 years of Port construction and operation, we anticipate approximately 50 percent males and 50 percent females will be killed by vessel strike.

Small populations are susceptible to threats such as inbreeding, genetic drift (allele frequencies of a population changing over generations due to chance), demographic stochasticity (chance independent events of individual mortality and reproduction, causing random fluctuations in population growth rate), and Allee effect (individual fitness in a population increases/decreases with increasing/decreasing population size because of undercrowding). These factors have substantial influence on the growth of small populations and therefore their extinction risk. The specific biology and life history of a species influence the population size needed to remain viable, but as a rule of thumb, an effective population size, N_e, of 50 breeding individuals are needed for a short-term minimum viable population (MVP) and a N_e size of 500 breeding individuals for retaining evolutionary potential (and long-term MVP) (Franklin 1980). The effective population "rule of thumb" for an Ne of 50 takes into account inbreeding while the latter considers genetic drift[32].

There are no abundance estimates for the entirety of the New York Bight DPS nor for either the Hudson or Delaware River populations. There are, however, some abundance estimates for specific life stages (e.g., natal juvenile abundance, spawning run abundance, and effective population size). As noted in the *Status of the Species* section (section 5), both the Delaware River and the Hudson River current abundance is believed to be a fraction of historic levels (also see Secor (2002) and Kahnle *et al.* (2007)). Although we do not have data to estimate the current adult population of Delaware River Atlantic sturgeon, we do have information that spawner runs consist of between 125 to 250 spawners (section 5.2.2). An estimated 3,656 age-1 individuals

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

used the Delaware Estuary as a nursery in 2014 (since oceanward migration begins at age two or older, these juveniles would be of Delaware River origin). An estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). In a more recent study, Kazyak *et al.* (2020) estimated the 2014 Hudson River spawning run size to be 466 sturgeon (95 percent CRI = 310-745). In our analysis below, we use a Delaware River spawner abundance of between 125 and 250 adults and a Hudson River spawner abundance of between 400 and 500 adults.

Based on genetic analyses of two different life stages, subadults and natal juveniles, Ne for the Delaware River population has been estimated to be 108.7 (95% CI=74.7-186.1) (O'Leary *et al.* 2014) and 40 (95% CI=34.7-46.2) (Waldman *et al.* 2019), respectively. Estimates for the Hudson River spawning population from the same studies are 198 (95% CI=171.7-230.7; (O'Leary *et al.* 2014)) and 156 (95% CI=138.3-176.1) (Waldman *et al.* 2019), respectively. Given the low Ne, genetic drift poses a threat to future genetic diversity of these populations. O'Leary *et al.* (2014) concluded that the populations likely would retain 95 percent of their alleles over the next century under current conditions. However, a decrease in longevity of mature adults would result in severe loss of genetic diversity (O'Leary *et al.* 2014).

The differences in estimated population size for the Hudson and Delaware River spawning populations and in Ne estimates of particular life stages further support the notion that the Hudson River spawning population is the more robust of the two spawning groups. This is also supported by the fact that Atlantic sturgeon originating from the Hudson River spawning population are more prevalent in mixed aggregations than sturgeon originating from the Delaware River spawning population as noted above. Still, while the size of the Delaware River and Hudson River populations cannot be determined with reasonable certainty, all available information indicates that both populations are below the long-term MVP. However, Grunwald *et al.* (2008)concluded that available information suggests that the straying rate is moderate (1.7 and 5.4 migrants/generation) between these rivers and even a straying rate of one per generation (given it includes successful reproduction) can mitigate genetic risks from genetic drift and inbreeding. Thus, the moderate exchange between the two rivers may mitigate some of the genetic risks associated with small populations (Mills and Allendorf 1996). However, this does not take into account other risks to small populations such as demographic stochasticity and catastrophic events.

We estimated that construction and operation of the proposed Port will add 75 juvenile, 87 adult, and 31 subadult Atlantic sturgeon dredge interaction and vessel mortalities from the New York Bight DPS to the baseline vessel mortality rate over the next 53 years. The loss of juveniles will reduce the number of adults in the future. However, the loss of 75 juveniles is a small percentage of the number of juveniles we expect occur in the Delaware River. The probability of a juvenile contributing to the adult population in the future is also small when taking into account mortality en route to maturity. Thus, we do not expect the loss of the juvenile Atlantic sturgeon to measurably affect future population growth of the Delaware River population. We do not have information about the total population or number of adults of either the Delaware or Hudson Rivers. However, using available information, we expect that the Delaware River spawning runs consist of between 125 and 250 individuals and the Hudson River runs consist of approximately 400 to 500 individuals (section 5). Based on the New York Bight life stages calculated above, the construction and operation of the Port will remove up to 20 adults and 7 subadults from the Delaware River population as well as 67 adults and 24 subadults from vessel strikes from the Hudson River over 53 years. We anticipate that this reduction in numbers from either river will be spread out over 53 years and is too small to affect genetic drift or inbreeding in a way that can be meaningfully evaluated. This is because of variation in the biological characteristics (number of progeny, male contribution, sex ratio, and population size) that affects the Ne and it is not possible to evaluate the contribution of one individual or the effect of losing a few individuals in a given year. Further, while the Delaware and Hudson populations are genetically distinct they are not genetically isolated. Even a small number of immigrants per generation is likely to reduce the risk of genetic drift (Mills and Allendorf 1996).

We also expect the reduction in the adult Delaware River population with 20 and the Hudson River with 67 adults over 53 years to be too small to increase the populations' vulnerability to demographic stochasticity, Allee effect, or other small population impacts on population genetics in a way that we can meaningfully measure or determine for either river or for the DPS as a whole. We expect that any vulnerability to catastrophic events will mostly depend on spatial structure of the populations and life history of the species. Current information from both the Delaware and Hudson River indicate that both rivers have multiple spawning sites. The loss of 20 adults in the Delaware or 67 in the Hudson River over 53 years is unlikely to measurably increase the vulnerability during an in-river catastrophic event. This is because we expect the effects of a catastrophic event (e.g., oil spill, pollutant release, etc.) to be more related to the concentration of spawners within a particular area than to the total number of spawners, and it is not possible to evaluate how a loss of 20 or 67 spawners spread out over 53 years will increase the vulnerability from a catastrophic event. Since Atlantic sturgeon adults do not spawn every year, migrating adults will buffer against catastrophic loss of a spawning population by reintroducing spawning individuals in following years.

At the DPS level, the loss of 87 adults from the New York Bight DPS over 53 years is not expected to reduce the ability of adults at large to reintroduce spawning in the event of a catastrophic loss of spawners. Assuming a 50/50 sex ratio, about 10 and 34 females from the Delaware River and Hudson River, respectively, will be lost over the 53-year period. Young-of-the-year and, to some extent, juveniles, typically aggregate and rear in waters with low salinity just above the River's salt front (e.g., the Marcus Hook range in the Delaware River). Any catastrophic event in a specific area (such as an aggregation area) could result in loss of all or most of that years' young-of-the-year as well as many juveniles in that area. However, even if there was a catastrophic event affecting Atlantic sturgeon spawning areas, we do not expect that the loss of up to 10 adult females from the Delaware River and 34 from the Hudson River populations over 53 years would significantly affect the outcome and consequences of a catastrophic event in either river considering the number of expected spawners in both the Delaware River and Hudson River together with the fecundity of adult female sturgeon and multiple rearing sites.

We have determined that the probability that the loss of 193 individuals over the life of the project will reduce genetic diversity is extremely small. Further, because the loss of 87 adults, 31 subadults, and 75 juveniles constitute a small loss in numbers over 53 years, it is unlikely that this loss will reduce the number of sexually mature individuals to an extent that will reduce either of the two river populations' or the DPS as a whole current ability to exist into the future while retaining the potential for recovery.

For a population to recover, production (i.e., population growth rate) has to be positive. A population with a negative population growth will eventually go extinct. However, a species remains prone to extinction as long as they remain small and, thus, the rate of population growth, even if positive, will influence survival and recovery. Blackburn *et al.* (2019) found that population growth of White Sturgeon in the Sacramento-San Joaquin Basin (SSJ) in California was most influenced by the survival of sexually mature adults. The population model suggested that White Sturgeon in the SSJ could reach the replacement rate (i.e., $\lambda \geq 1.00$) if total annual mortality for age-3 and older fish does not exceed 6 percent. Low levels of exploitation (i.e., <3 percent) would likely be required to maintain a stable population. For Atlantic sturgeon, ASMFC (2007) concluded that a 5 percent bycatch mortality of adults was not sustainable. Brown and Murphy (2010) similarly concluded that the loss of 2.5 percent of females per year from vessel strikes would hamper recovery of the Delaware River Atlantic sturgeon population. Further, variation in abundance over time affects extinction risk. Higher variation increases the probability of population bottlenecks that may decrease genetic variation and population fitness, the probability of the population being reduced to levels where its productivity is at or below depensation (i.e., a decrease in breeding individuals reduced production and survival of offspring), and increases the risk of real (i.e., no living members of a population remain) or functional extinction (i.e., the population has individuals still living, but the numbers are too small to support recovery). Mortality, fecundity, and generation time determines population growth. Variations of any of these three factors can result in variations in abundance over time.

No data exists that can be used to determine productivity for the Delaware River since the time the New York Bight DPS was listed. However, DO conditions in the river have improved markedly over past decades such that sturgeon are now able to use previously degraded spawning and rearing areas in the lower tidal river. This may have increased access to spawning areas and improved juvenile survival and productivity. However, significant vessel traffic, industrial activity, and contaminated bottom substrate in these reaches exposes sturgeon to multiple threats (section 6).

The Commission's 2017 benchmark stock assessment concluded that there was a relatively high probability that the abundance of the New York Bight DPS has increased since the implementation of the 1998 fishing moratorium (ASMFC 2017b). However, there was considerable uncertainty expressed in the stock assessment and in its peer review report. New information suggests that the conclusion about the New York Bight DPS primarily reflects the status and trend of only the DPS's Hudson River spawning population (NMFS 2022). Annual surveys for Atlantic sturgeon juveniles in the Hudson River conducted by the New York State Department of Environmental Conservation (NYDEC) since 2004 suggests that the catch rate of juvenile Atlantic sturgeon has increased, with double the average catch rate for the period from 2012-2019 compared to the previous eight years, from 2004-2011 (Pendleton and Adams 2021). However, this does not provide enough information to discern any trend in the Hudson River population's growth rate. Nevertheless, given the results of the benchmark stock assessment and the NYDEC surveys, the Hudson River population may have a positive growth rate.

The proposed project will not affect the reproductive potential of the Delaware River and Hudson River populations in any way other than through a reduction in numbers of individuals. We determined that the construction and operation of the Port will result in the mortality of 75 juvenile, 87 adult, and 31 subadult New York Bight DPS Atlantic sturgeon. Mortalities have the potential consequences of reducing reproduction potential, as any dead New York Bight DPS Atlantic sturgeon has no potential for future reproduction.

The loss of 75 juveniles is a very small contribution to a cohort as the current spawning in the Delaware River likely produces several thousand juveniles each year and the expected contribution to population growth by a single juvenile is relatively small when taking into account mortality en route to maturity. Therefore, this represents a small reduction in potential future female spawners for the Delaware River and in the number of eggs laid or larvae produced by the population in future years. Assuming that the Delaware River adult population consists of 75 to 125 spawning females (with a 50/50 sex ratio), then the annual loss of greater than 2.5 percent of female sturgeon from vessel strikes could be detrimental to the population (Brown and Murphy 2010). We expect that the construction and operation of the Edgemoor Port will cause the mortality of 10 adult females from the Delaware River population and 34 adult females from the Hudson River population over 53 years. Though vessel strike mortalities may not be evenly distributed over the 53 years, they equal an average of less than one adult, female sturgeon per year for both rivers. If half of the mortalities are females, then the average mortality in the Delaware River equals about one female every five years. For the Hudson River, vessel mortalities will average 0.66 or less than one per year. This equals 0.26-0.33 percent of female spawners annually. If all 87 sturgeon adult mortalities were females, it would result in an average mortality of three every other year. Either way, for both river populations, the mortality does not exceed what was considered sustainable in the studies referenced above. These calculations do not take into account that the female population also includes non-spawning females and, thus, we expect the actual total adult female population to be higher for both rivers. If one considers the consequences for the New York Bight DPS as a whole, then the loss constitutes an extremely small percentage. Using the NEAMAP study, we concluded that the DPS consists of approximately 8,642 adults (Table 7). If 87 vessels strikes over the 53-year period are adults then the proposed project will kill less than 1 percent of New York Bight DPS spawners or 0.5 percent of females over 53 years. We expect the loss of the 75 juvenile, 87 adults, and 31 subadults over a 53-year period to be too small to increase variation in abundances over time to such an extent that it can be meaningfully measured or evaluated.

Here, we consider how these mortalities will affect productivity when added to other anthropogenic mortalities of females from the two river populations. New York Bight 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. Bycatch in federal fisheries accounts for one of the largest known number of anthropogenic mortalities, but our review concluded that bycatch is not likely to jeopardize the continued existence of the Atlantic sturgeon New York Bight DPS (NMFS 2021). Bycatch and mortality also occur in state fisheries; however, the primary fishery that impacted juvenile sturgeon (the shad fishery) has now been closed in the Hudson River and there is no indication that it will reopen. Commercial shad fishery continues in the Delaware Bay but is closed in the Delaware River. New York

Bight DPS Atlantic sturgeon are killed as a result of other anthropogenic activities in the Hudson, Delaware, and other rivers within the DPS as well, which may impact early life stages and natal juveniles as well as migratory subadults and adults. Sources of mortality in particular include vessel strikes (e.g., section 6.7.3). Other anthropogenic mortalities include occasional entrainment in dredges and entrainment in cooling water intakes at power stations. These activities are ongoing, thus influencing the baseline upon which this analysis is founded. While we do not have an estimate of the total number of anthropogenic mortalities per year, we do not expect that the additional mortality of adults from this proposed action will change the status of either river population or the DPS as a whole. This is because they contribute a very small number of mortalities relative to the total populations and these mortalities will occur over time. As previously discussed, individual females do not spawn every year, thus allowing time for new spawning events to occur after mortalities occur over time. Based on the above considerations, we do not expect the proposed project to affect productivity of either the Delaware River or Hudson River populations or the DPS as a whole. We have not identified any cumulative effects that will substantially affect productivity.

In conclusion, 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 of both riverine populations and the New York Bight as a whole is anticipated to be small and would not change the status of this species. The proposed action will not affect the spawning grounds within the rivers where New York Bight DPS fish spawn, as we do not expect the proposed action to affect spawning substrate or salinity. The action will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by New York Bight DPS fish. Thus, the proposed action will not result in a loss of individuals or cause impacts to the environment that will reduce the number of sexually mature individuals producing viable offspring to an extent that will reduce either population's current ability to exist into the future while retaining the potential for recovery.

The proposed action is not likely to reduce distribution because the action will not impede New York Bight DPS Atlantic sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds in the Delaware River or elsewhere. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of areas near in-water construction activities.

Last, we have considered if climate change will affect our above conclusions with regard to the consequences to survival and recovery of losing 75 juveniles, 87 adults, and 31 subadults. As described in section 7.2.1, over the long term, global climate change may affect New York Bight DPS Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect New York Bight DPS Atlantic sturgeon in the action area. 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 New York Bight DPS Atlantic sturgeon will be able to successfully adapt to any such changes. While we can make some predictions on the likely effects of climate change on these species and critical habitat, without modeling and additional scientific data, these predictions remain speculative, and we have concluded that the occurrence of climate change will not change our determinations.

The New York Bight DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently not enough information to establish a trend for any life stage or for the DPS as a whole. However, since the proposed Port is unlikely to affect the viability of the Delaware River or Hudson River populations, we do not expect the estimated loss of 75 juvenile, 87 adults, and 31 subadults to diminish the DPS' numbers, reproduction, or distribution so that the likelihood of survival is appreciably reduced.

Based on the above, we have determined that the action will not affect New York Bight DPS Atlantic sturgeon in a way that will change the status of the DPS or prevent the species from achieving 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 effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of these New York Bight DPS Atlantic sturgeon as a result of this action over a 53-year period will not reduce the current status the Delaware River and Hudson River populations; (2) the death of these New York Bight DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these New York Bight DPS Atlantic sturgeon is not likely to have effects on the levels of genetic heterogeneity in the species; (4) the loss of these New York Bight DPS Atlantic sturgeon is likely to have such small effects 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 New York Bight 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 New York Bight DPS Atlantic sturgeon to shelter with only an insignificant consequence on individual foraging New York Bight DPS Atlantic sturgeon when considering that the footprint of the dredging site is small relative to available forage within the action area and 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 New York Bight 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 New York Bight DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the New York Bight 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 New York Bight DPS Atlantic sturgeon over time and will not affect the overall distribution of New York Bight 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 Atlantic sturgeon using the Delaware River estuary. The proposed action will result in a small amount of mortality (no more than 193 individuals over 53 years) and a subsequent small reduction in future reproductive output. For these reasons, the action is not expected to affect the persistence of the New York Bight DPS of Atlantic sturgeon. Additionally, the action will not change the status or population trend of the New York Bight 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 New York Bight 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 New York Bight 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 New York Bight 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 193 New York Bight DPS Atlantic sturgeon over a 53-year period, is not likely to appreciably reduce the survival and recovery of this species.

Chesapeake Bay DPS

The Chesapeake Bay 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 5.2.2.8). 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 2017).

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 Chesapeake Bay DPS Atlantic sturgeon is 8,811 sub-adult and adult individuals. The ASMFC (2017b) stock assessment determined that abundance of the Chesapeake Bay 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 Chesapeake Bay DPS has increased since the implementation of the 1998 fishing moratorium, and a 30 percent probability that mortality for the Chesapeake Bay DPS exceeds the mortality threshold used for the assessment (ASMFC 2017b).

We anticipate the mortality of up to 61 adult or sub-adult Chesapeake Bay DPS Atlantic sturgeon as a result of vessel interactions during the 53-year period. Take of Chesapeake Bay DPS is anticipated during the 50 years of operations at the Port. Thus, here, we consider the consequences of the loss of up to 61 Atlantic sturgeon over a 50-year period from the Chesapeake Bay DPS. The reproductive potential of the Chesapeake Bay DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of up to 61 individuals over a 50-year period will have the consequence of reducing the amount of reproduction potential as any dead Chesapeake Bay 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 61 Chesapeake Bay 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 Chesapeake Bay 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 Chesapeake Bay DPS fish for the same reasons.

Because we do not have a population estimate for the Chesapeake Bay 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 61 individual sturgeon over the 50 years of Port operation, or an average of 1.1 mortalities each year, it is unlikely that these deaths will have a detectable consequence on the abundance and population trend of the Chesapeake Bay DPS.

The proposed action is not likely to reduce distribution of the Chesapeake Bay 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 Chesapeake Bay 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 61 Chesapeake Bay DPS Atlantic sturgeon over 50 years of Port operations will not appreciably reduce the likelihood of survival of the Chesapeake Bay 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 Chesapeake Bay 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 61 Chesapeake Bay DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (2) the loss of these Chesapeake Bay 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 Chesapeake Bay 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 Chesapeake Bay DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging Chesapeake Bay 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 Chesapeake Bay 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 Chesapeake Bay DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the Chesapeake Bay 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 Chesapeake Bay DPS Atlantic sturgeon and it will not affect the overall distribution of Chesapeake Bay 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 50 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 Chesapeake Bay DPS of Atlantic sturgeon. This action will not change the status or trend of the Chesapeake Bay 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 Chesapeake Bay 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 Chesapeake Bay 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 Chesapeake Bay 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 61 Chesapeake Bay DPS Atlantic sturgeon over a 50 year period, is not likely to appreciably reduce the survival and recovery of this species.

South Atlantic DPS

The South Atlantic DPS is listed as endangered and Atlantic sturgeon originate from at least six rivers where spawning potentially still occurs. Secor *et al.* (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 *et al.* (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 South Atlantic 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 South Atlantic 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 South Atlantic DPS Atlantic sturgeon sub-adults and adults is 14,911 individuals.

The 2017 ASMFC stock assessment determined that abundance of the South Atlantic DPS is “depleted” relative to historical levels (ASMFC 2017b). Due to a lack of suitable indices, the assessment was unable to determine the probability that the abundance of the South Atlantic 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 South Atlantic DPS exceeds the mortality threshold used for the assessment (ASMFC 2017b).

We anticipate the mortality of up to 51 South Atlantic DPS adult or sub-adult Atlantic sturgeon as a result of the proposed project. Take of South Atlantic DPS is only anticipated during the 50 years of operation of the Port. Thus, here, we consider the consequences of the loss of up to 51 South Atlantic DPS Atlantic sturgeon over a 50-year period. The reproductive potential of the South Atlantic DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of up to 51 individual sturgeon over a 50-year period would have the consequence of reducing the amount of reproduction potential, as dead South Atlantic 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 South Atlantic 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 South Atlantic DPS fish for the same reasons.

Because we do not have a population estimate for the South Atlantic 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 51 individuals over a 50-year period, or an average of 0.9 mortalities each year, it is unlikely that this death will have a detectable consequence on the numbers and population trend of the South Atlantic 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 South Atlantic 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 51 South Atlantic DPS Atlantic sturgeon over a 50-year period will not appreciably reduce the likelihood of survival of the South Atlantic 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 South Atlantic 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 South Atlantic 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 51 South Atlantic DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (2) the loss of these 51 South Atlantic DPS Atlantic sturgeon is not likely to have consequences on the levels of genetic heterogeneity in the population; (3) the loss of these South Atlantic DPS Atlantic sturgeon over a 50-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 South Atlantic 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 South Atlantic DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging South Atlantic 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 South Atlantic 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 South Atlantic 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 South Atlantic DPS Atlantic sturgeon and it will not affect the overall distribution of South Atlantic 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 51 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 South Atlantic DPS of Atlantic sturgeon. This action will not change the status or trend of the South Atlantic 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 South Atlantic 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 South Atlantic 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 South Atlantic 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 51 South Atlantic DPS Atlantic sturgeon over a 50-year period, are not likely to appreciably reduce the survival and recovery of this species.

Carolina DPS

The Carolina DPS is listed as endangered. Atlantic sturgeon from the Carolina DPS spawn in the rivers of North Carolina south to the Cooper River, South Carolina. There are currently seven spawning subpopulations within the Carolina DPS: Roanoke River, Tar-Pamlico River, Neuse River, Northeast Cape Fear and Cape Fear Rivers, Waccamaw and Great Pee Dee Rivers, Black River, Santee and Cooper Rivers. NMFS estimated adult and subadult abundance of the Carolina 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) and concluded that subadult and adult abundance of the Carolina DPS was 1,356 sturgeon (339 adults and 1,017 subadults) (NMFS 2013). This number encompasses many age classes since, across all DPSs, subadults can be as young as two years old when they first enter the marine environment, and adults can live as long as 64 years (Balazik et al. 2012; Hilton et al. 2016).

The 2017 ASMFC stock assessment concluded that abundance of the Carolina DPS is "depleted" relative to historical levels and there is a relatively low probability (36 percent) that abundance of the Carolina DPS has increased since the implementation of the 1998 fishing moratorium. The ASMFC also concluded that there is a relatively low likelihood (25 percent probability) that mortality for the Carolina DPS does not exceed the mortality threshold used for the Stock Assessment (ASMFC 2017).

We anticipate the mortality of up to 2 Carolina DPS adult or sub-adult Atlantic sturgeon as a result of the proposed project. Take of Carolina DPS is only anticipated during the 50 years of operation of the Port. Thus, here, we consider the consequences of the loss of up to 2 Carolina DPS Atlantic sturgeon over a 50-year period. The reproductive potential of the Carolina DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of up to 2 individual sturgeon over a 50-year period would have the consequence of reducing the amount of reproduction potential, as dead Carolina 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 Carolina 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 Carolina DPS fish for the same reasons.

Because we do not have a population estimate for the Carolina 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 2 individuals over a 50-year period, or an average of 0.04 mortalities each year, it is unlikely that this death will have a detectable consequence on the numbers and population trend of the Carolina 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 Carolina 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 2 Carolina DPS Atlantic sturgeon over a 50-year period will not appreciably reduce the likelihood of survival of the Carolina 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 Carolina 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 Carolina 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 2 Carolina DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (2) the loss of these 2 Carolina DPS Atlantic sturgeon is not likely to have consequences on the levels of genetic heterogeneity in the population; (3) the loss of these Carolina DPS Atlantic sturgeon over a 50-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 Carolina 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 Carolina DPS Atlantic sturgeon to shelter with only an insignificant consequence on any foraging Carolina 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 Carolina 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 Carolina 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 Carolina DPS Atlantic sturgeon and it will not affect the overall distribution of Carolina 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 2 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 Carolina DPS of Atlantic sturgeon. This action will not change the status or trend of the Carolina 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 Carolina 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 Carolina 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 Carolina 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 2 Carolina DPS Atlantic sturgeon over a 50-year period, are not likely to appreciably reduce the survival and recovery of this species.

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, PBF 1 does not occur within the action area, and all consequences of the action on PBFs 3, and 4 are insignificant and/or extremely unlikely to occur.

Dredging of the access channel, turning basin, and berth (87 acres) will occur within habitat we have identified as PBF 2. There will be a loss of habitat within the dredge footprint during the up to 3 years of construction of the Port. We anticipate that use of the Port channels by deep draft vessels will continue to reduce the value of PBF 2 during 50-years of Port operations. Thus, the proposed project will result in the removal of 87 acres of PBF 2 over a three-year period during construction and a continued degradation of the 2,230 acres of the Federal Navigation Channel from RKM 78 to RKM 118 (RM 48.5 to RM 73.3) during 50 years of operation.

As explained in section 9.2, this 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 the action affects that role.

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 degradation of 2,317 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 degradation of 2,317 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 degraded is a small proportion (6.7%) of the 34,240 acres of PBF 2 identified between RKM 78 and 118 (RM 48.5 and 73.3) within the oligohaline zone of the Delaware River. 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. Also, PBF 2 within the Navigation Channel is likely degraded due to the regular impact from the prop wash of thousands of deep draft vessels traveling up and down the Channel;

(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 Gulf of Maine, New York Bight, Chesapeake Bay, South Atlantic, and Carolina 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 Diamond State Port Corporation (i.e., DSPC or applicant) for construction of a port facility (i.e., the Port). The USACE will permit the in-water construction components of the Port’s facilities as well as the dredging of the Port’s access channel, turning basing, and berths. The USACE has authority to ensure compliance with RPMs and Terms and Conditions related to the dredging and pile driving during construction of the Port.

During operation of the Port, cargo vessels will call at the Port. Because the specific deliveries are not known at this time, we cannot say where the vessels will travel during operation of the Port, or from where the 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 Port and the mouth of the Delaware Bay will cause vessel strike mortalities of Atlantic sturgeon and shortnose sturgeon[33].

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

[33] The proposed action may affect, but is not likely to adversely affect right whales, fin whales, green sea turtles, loggerhead sea turtles, Kemp’s ridley sea turtles, leatherback sea turtles; therefore, we do not anticipate any incidental take of those species.

from the proposed action. The USACE has authority to ensure compliance with RPMs and Terms and Conditions related to collecting data about the number of vessels calling at the Port during its operations. The Port owner/operator has authority over vessels as they travel through the access channel to and from the Port itself. They also have authority over operation of the Port and number of vessel calls. As such, "applicant only" RPMs and Terms and Conditions, which are necessary and appropriate to monitor incidental take resulting from the expected 50 years of Port operations, 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 the 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 New York Bight Atlantic sturgeon from entrainment in cutterhead dredge and vessel strike by construction vessels. We also anticipate that the long-term operation of the Port will cause vessel strikes of Atlantic sturgeon New York Bight, Gulf of Maine, Chesapeake Bay, South Atlantic, and Carolina DPSs as well as shortnose sturgeon.

13.1.1 Take over the Life Span of the Port

Take incidental to the proposed action and activities caused by the proposed project is outlined below (Table 45). 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 45. Total exempted incidental lethal take resulting from dredging, vessel strikes by construction vessels, and vessel strikes during the long-term operation of the Port.

Species	Lethal
Shortnose Sturgeon	**Up to59**
Atlantic Sturgeon	**Up to 340**

Sturgeon Take Incidental to Cutterhead Dredging of the Port and Access Channel

We expect cutterhead dredging to kill up to three (3) sturgeon (no more than one per dredge cycle). These may be juvenile shortnose sturgeon or juvenile New York Bight DPS Atlantic sturgeon.

Sturgeon Take Incidental from Vessel Traffic During Port Construction

We expect that sturgeon interacting with construction vessels during construction of the Port will result in the mortality of six (6) shortnose sturgeon and fourteen (14) Atlantic sturgeon. The shortnose sturgeon may be a juvenile or an adult. The Atlantic sturgeon will be three (3) juveniles and 11 adults of the New York Bight DPS.

Sturgeon Take Incidental from Vessel Traffic During Long-term Operation

We expect up to 373 lethal vessel strikes during operation of the Port. Of these:

- Up to 50 shortnose sturgeon juveniles, adults, or mix of the two
- Up to 69 juvenile Atlantic sturgeon from NYB DPS
- Up to 76 adult Atlantic sturgeon from NYB DPS
- Up to 31 subadult Atlantic sturgeon from the NYB DPS
- Up to 61 adult/subadult Atlantic sturgeon from CB DPS
- Up to 51 adult/subadult Atlantic sturgeon from SA DPS
- Up to 33 adult/subadult Atlantic sturgeon from GOM DPS
- Up to 2 adult/subadult Atlantic sturgeon from the Carolina DPS

Summary Total Incidental Take

This level of take (up to 59 shortnose sturgeon and up to 340 Atlantic sturgeon) is expected to occur over the entire period that comprises the construction and operational lifespan of the Port (e.g., 53 years), and is not likely to jeopardize the continued existence of listed species.

This incidental take is for the whole period of construction and 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 permit issuance. 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 Port 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 Port. Based on this analysis, we estimate that vessels calling at the Port and associated support tugs will cause 323 Atlantic sturgeon and 50 shortnose sturgeon vessel strike mortalities over a 50-year period. We also estimated that vessel traffic during the up to three years of constructing the Port would result in construction vessels killing 14 Atlantic sturgeon and 6 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 110 vessel trips and a shortnose sturgeon for every 1,000 vessel trips. This estimate provides a surrogate for monitoring the amount of incidental take during operation of the Port. Therefore, in discussions with the USACE and DSPC, we concluded that incidental take associated with operation of the Port can be monitored by the USACE reporting the annual number of vessel calls at the Port. This will be used as the primary method of determining the amount of incidental take and whether it has been exceeded. 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 the number of vessel calls at the Port.

We also conclude in the *Consequences of the Action* section that vessel activity during construction of the proposed dredging of the access channel will increase the risk of vessel strike in the river channel off the Port and in the Federal Navigation Channel between the Port site and the Port of Wilmington. We similarly based the estimated take on anticipated number of vessel trips that will occur each of the up to 3 years of construction. The number of 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.

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 14 Atlantic sturgeon: 14 takes via surrogate or two observed in the dredge spoil and 12 via surrogate, etc.):

- any additional vessel call, or
- any additional observed take 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 46 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 45, 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 46. 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 the number of vessel calls at the Port to estimate take of sturgeon to assure that take is not exceeded.	1. During construction of the Port, USACE shall report to us on an annual basis 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 the end of the work window on March 14 (Year 1). The second report shall cover the period from March 15, 2023, to March 14(Year 2). USACE shall provide the reports to us by April 15 (Year 1), and April 15, (Year 2). If construction is not completed by March 15 (Year 3) then USACE shall provide a report for the remaining construction period once the construction is completed and no later than April 15 (Year 3). 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 described 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. c. The number of tugs at the Port that are supporting the construction of the	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. 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
	wharf. d. The number of tugs during each dredge period that supported dredging activities. 2. Until year 49 of operations of the Port (unless modified as noted below when 80% of vessel trips projected have occurred), at the beginning of each calendar year and no later than March 1, the USACE during the life of the permit (NAP-OP-R-2019-278) 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.gov to provide us with: a. The total number of vessel calls at the Port the previous year b. The number of vessels that called at the Port by month c. Type of vessels and their drafts that called at the Port The correspondence must reference the name of the project (i.e. Edgemoor) and our file number (GARFO-2021-03472). 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. When 80 percent of the estimated total vessel trips have occurred or in the final year of operation (i.e., year 50), whichever comes first, the USACE or the applicant shall	

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	provide the following information on a quarterly basis to ensure that the authorized take is not exceeded i.e., the USACE or the applicant must contact us at incidental.take@noaa.gov and provide the following information by April 30, July 31, October 31 and January 31: d. The total number of vessel calls at the Port the previous year e. The number of vessels that called at the Port by month f. Type of vessels and their drafts that called at the Port The correspondence must reference the name of the project (i.e. Edgemoor) and our file number (GARFO-2021-03472). If the permit is renewed, USACE shall contact us to discuss this RPM and TC.	
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	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.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	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).	
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 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 Port, USACE shall notify us of any suspected sturgeon vessel strikes or dredging mortalities. The Applicant shall provide to the USACE the number of	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 represent only a minor change as compliance will not delay 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
	and the date the sturgeon was 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 Project Area or along the shores of Edgemoor. 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.	
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 or vessel strike. We shall have the final say in determining if the take should count towards the Incidental	These RPMs and TCs are necessary and appropriate to ensure the documentation of any interactions with listed species as well as requiring that these interactions are reported to us in a timely manner with all of the necessary information. In some cases, when the cause of death is uncertain, a necropsy may be necessary to aid in the determination of whether or not a mortality should count toward the ITS. This is essential for monitoring the level of incidental take associated with the proposed action. These RPMs and TCs represent only a minor change as compliance will not result in any increased cost, delay of the project or decrease in the efficiency of the dredging operations

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	Take Statement.	
5. 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 or vessel 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 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		
6. 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 observers 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.	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

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (TCs)	Justifications for RPMs & TCs
	Documents and forms that shall be available on vessels or dredges include: • Standard Operating 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)	injury are minimized.
7. 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 screening of dredge material by observers is not required.	These RPMs and TCs are necessary and appropriate as they serve to ensure that sturgeon have a minimized risk of injury or mortality from cutterhead dredging activities. 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.

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 New York Bight 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 standardizes 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 DSPC associated with construction of the Edgemoor Container 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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